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PLATE I.

[*Frontispiece.*

RUDIMENTARY TREATISE ON THE

ERECTION OF

DWELLING-HOUSES

ILLUSTRATED BY

A PERSPECTIVE VIEW, PLANS, ELEVATIONS, AND SECTIONS OF A PAIR OF SEMI-DETACHED VILLAS

WITH

The Specification, Quantities, and Estimates

AND EVERY REQUISITE DETAIL, IN SEQUENCE, FOR THEIR CONSTRUCTION AND FINISHING

By S. H. BROOKS, Architect

SEVENTH EDITION, THOROUGHLY REVISED

LONDON
CROSBY LOCKWOOD AND SON
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1896

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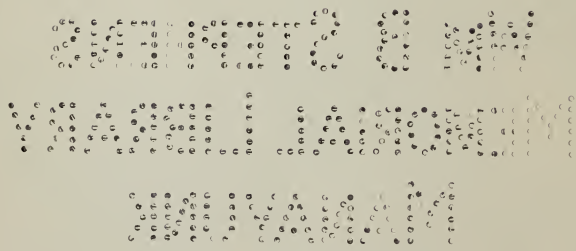

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PREFACE

In our professional practice we have frequently been applied to for a treatise on Building, to which the young student in Architecture, as well as in Building, might refer and see, in an erection of simplicity or splendour, the necessity of studying all the details essential for such erection. In the office of the Architect, it frequently occurs that Buildings, from the variableness of practice, are only taken in detached parts as the work proceeds; and in the workshop of the Builder (*where they have drawings and specifications to work from*), the workman, or pupil, is seldom allowed to see them, but takes his instructions from the foreman for the portion of work to be executed; consequently he has little opportunity of acquiring the combined information requisite for the artisan in the building department to possess.

Under such considerations the present work was projected by Mr. Weale, the publisher of the rudimentary works on the Arts and Sciences.

We have, in this sketch of a pair of dwellings, endeavoured to show and describe the manner in which a building, from the commencement of it to its com-

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pletion, should be dissected and studied in its various mechanical departments, and how they work and combine with each other.

We first submit a set of probationary drawings, all drawn to the same scale, and then show the requisite details, as they would generally occur, for the completion of the carcass, and, lastly, the finishings. We have also divided the specification, quantities, and estimates, into corresponding parts. It may not always be desirable to make such a distinction, but this being a rudimentary work, we have adopted this method in order to make it as intelligible as possible to the student in the Building art. We have also given as much attention to the drainage, supply of water, ventilation, &c., as the importance of such an erection demands.

It may be proper to observe, that we have not strictly conformed to the Metropolitan Building Act, but have endeavoured to show how to erect a substantial building with every attention to the prevention of such casualties as buildings of this class are frequently liable to.

In submitting this as one of a series of designs with their details, allow us to acknowledge the information quoted from the rudimentary series of scientific works before alluded to, as we have freely referred to any of them that would assist us in conveying our views in the theoretical and practical construction of buildings. Perhaps no one is more liable to criticism than the architect for domestic arrangements; consequently

there are few who devote their time to it. An architect justly observes: to produce a building fit for its purposes, and substantially beautiful at the same time, is a good step towards perfection. And probably the allusion to street architecture might with benefit be here quoted.

It is stated that, in alluding to the building at the corner of Fleet Street and Chancery Lane:—"It is a good step towards that perfection which the commercial architecture of the metropolis may reach. Fleet Street and the Strand, transformed into a succession of such edifices, might become a worthy Corso for the trading Rome, and make a grand connecting point between the region of docks and warehouses at one end, and of mansions and palaces at the other."

The building referred to is an example of a commercial edifice. It were better, indeed, that the elements of mercantile life were exemplified in its habitations. We have surely had enough of doubtful objects in stucco, &c.: sober and straightforward, not uncomely, are the operations of upright tradesmen; so let their offices, warehouses, and shops, be truthful, substantial, cheerful, ornamental piles. Thought is not thrown away when applied to the improvement of our streets and mercantile edifices. A man will carry on his affairs with a healthier and clearer mind, surrounded by buildings of the class we are now writing about, than in such dens of darkness as some of the buildings in the neighbourhood of Chancery Lane.

There is such correspondence between outward forms

and shows, and inner feelings and emotions, in all truthful matters, that it is far from an affair of indifference in what manner of form we transact our commerce, with what impress of form we endow our churches, or in what fashion of apartments we meet our friends and children. Providence has arranged this world upon these considerations (*so to speak*), and surrounded parts of the earth with cheerfulness and healthful beauties.

We, who in our offices and ledgers have often little enough thought of Providence, shall we esteem it indifferent whether we follow *His* precepts here, where, perhaps, we need their healthful influence most?

To architects, at least, this question is not unimportant, in an architectural point of view; for it is in such we speak. As a sanitary question, these things are happily decided.

The importance of domestic architecture must be held in a very different estimation to what it has been, by any one who hopes to assist in the revival of all architecture, dead since the sixteenth century in our country.

We are a commercial people, and a common-sense trading race; he who can find a brotherhood in architecture with the great republics of mediæval Italy, the commercial communities of Florence, Genoa, Sienna, will perceive nothing but a source for the highest gratulations. We shall have our San Michele, Sansovino, &c. We, too, may become, amid this Kaleidoscope Europe, a stand-point of light for the

after-times to reckon from; but, to achieve this we must recognise and know ourselves. We must develop and not conceal our nationality, in arts as in all things else. From the streets of our cities and manufacturing towns, our wealth and power proceed. Let these become the stepping-stones to our temples; as they must do, if our temples and our worship are to be sincere. It is not by forgetting, but remembering, our commercial street-life that we shall become a people great in wisdom as in wealth.

And, indeed, why should words be multiplied about the matter? It is from these things that we are growing a wise, and, so much as there is of it, a holy people. From counting-houses, offices, warehouses, and chambers, come the schemes for baths and wash-houses, and model dwellings, ragged schools, and reformatory asylums. There on one side the genius of the shop-keeping people make them; beyond them burns the glory of future England. What if, on the other side, those who have no work to do embroider mediæval patterns and multiply Gothic churches over the land? Let us be grateful that they do so much.

But meanwhile the architects have work to do; the public demands its streets and warehouses. Let us bear in mind how great these things are in their destinations—not, truly, all cheating and adulteration—let us remember that we are erecting buildings to-day through which the future contemplate, and the dwellers therein are preparing the paths of truth by their duties and their charities.

Let us then look upon those buildings and streets in their proper light, and build as if building for honourable men: to give our minds tone, let us discipline them to see in this shop-keeping what promise of greatness it encloses; and, recognising the nature of the times, perceive that it is in these very streets that the way is opened for us to commence our stone daguerreotype of the nineteenth century.

Architects are the limners for the future; to them is perhaps entrusted the verdict which remotest times will form. All else will go, as it has gone, of Art and man's production. But Architecture, that substitute for Nature, is nourished by time as the fossil history of mankind; and as the shells which the nautilus and ammonite of the primæval world have formed, become to us the sure records and interpreters of their far-departed times; so these shells under which animal life has dwelt, which religion has formed and inhabited, will become, may-be, to future races the only and fossil records whence the epoch of man shall be clearly read. For us, then, who have to mould these latest medals of creation, there is the responsibility that we rightly represent our race—our age; it is not surely all untruthful. We forge the long chain of antique history link by link—almost from architectural remains: from these we deduce a people and a history for our edification, instruction, and example. Regarded in this light, study will soon disclose to us what valuable and unique opportunity domestic architecture affords in our time. There are yet higher

views, under whose radiance the architect begins to perceive the great influence and responsibility of his work. But the consideration of what, and how great effect upon the mind, external objects exert, may be explained on another occasion.

After thus adverting to street and mercantile architecture, we would solicit some little attention to that style suitable and applicable for domestic purposes or dwellings, that may be proposed to be erected in the suburbs or environs of such as Cities, Towns, or Boroughs, before alluded to. For wherever our places of business assume a different and more healthy character for their various purposes, and in their erection a more permanent and architectural feature, the dwellings, cottages, villas, mansions, &c., of the surrounding country approximate, in a corresponding extent, with such improvements, and, consequently, the buildings for domestic purposes become equally combined with other classes of architecture, a reflection and monument of the people, and a key to the date of their erection. It was by witnessing this laudable improvement that is daily taking place in this City and other parts of the country, and in acquiescence with numerous applications for a series of designs suitable for the domestic arrangement and social comfort of all grades of society, the present works were projected. It is admitted that much ignorance exists as to the necessary knowledge in the erection of an edifice, however simple: and this is a powerful drawback to the execution of such undertakings. It is

also proverbial that false estimates, which are frequently tendered, dishearten many from the prosecution of their plans, in the well-founded suspicion that the expenditure will exceed the means appropriated for that purpose.

In the erection of an edifice, much depends on the choice of materials, whether for fitness or durability; and a correct guide in the selection of them, on the most cheap and economical principles, cannot therefore but be regarded as a desideratum by every one connected with or concerned in building, whether for profit or private purposes. An elaborate and explanatory specification, with the quantities of the various materials required in each department, their prices, the amount of labour and price required for working them, with accompanying design, so that any one about to build may arrive at the total expense before commencing; the most approved and efficient methods of water supply, drainage, warming, ventilating, according with the magnitude of the design, will form an important feature of *the work*. We have commenced our *series* with a design for a pair of semi-detached dwellings, the estimated expense of each of which would be about £600, or £1,200 the pair; thereby giving a selection for the retired tradesman, or the gentleman of moderate wealth who may wish to build over his own demesne, fully detailing the most approved and efficient methods of construction, as well as finishings, as a guide to the various trades employed in the building art.

Each design is exemplified with a perspective view of the building, accompanied with all requisite plans, elevations, sections, and details, drawn to a large scale; thereby making this volume a work of instruction to the student and builder, and one of reference to the professional practitioner in all his requirements.

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ON THE

ERECTION OF DWELLING-HOUSES.

CHAPTER I.

When it is determined to erect an edifice of any description, the first and primary consideration should be the money intended to be expended; the next, when possible, the choice of situation, not only as respects its efficient drainages, dryness, and general healthiness, but also as regards its relative position with other buildings, and, when a number are proposed to be erected on a new site, to their being so placed as not to interfere with or injure the effect of the surrounding scenery. Consequently, it is desirable, after a space of ground has been appropriated for building purposes, surveyed, levelled, plotted, &c., that a perspective bird's-eye view should accompany the plans, not so much that the design there exhibited should be carried into execution, but that they shall not interfere with the principal prospect, and as little as possible intercept the view or prospect of each other.*

The "lamentable way in which the beauty and loveliness of the finest landscape may be injured or destroyed by buildings and grounds is exemplified by the far-famed view from the top of Richmond Hill. What it

* Mr. C. B. Allen's "Cottage Building" vol. 42 of this series.

was when Thomson wrote it would perhaps be difficult to say; but now—instead of the houses and villas, and the gardens about them, harmonising with and forming a part of the general view to be examined in detail—after the eye is satiated with the whole, it is first struck with the glaring newness *(for they all seem as if they were painted and pointed regularly once every year)* of first one and then another of these regularly built boxes placed in the middle of a large square garden or lawn, and surrounded by a high fence, and the country round being thickly wooded close up to the wall, the formality of the grounds is rendered truly distressing."

A landscape made up of a collection of square fields, surrounded by regular hedge-rows, and dotted here and there with cubical, newly-painted boxes and straight roads, may satisfy, as it commonly does, the owners of the several lots, but can never be otherwise than painful to the eye of an artist. But what is called landscape scenery in England is mostly of this description, and appears to be admired on the ground of its cultivation and plenty, qualities perfectly distinct from it, considered as a beautiful object.

If any general rule could be given for the laying out of building grounds, it would be to avoid everything considered essential—long rows of houses all of the same height, semi-circular rows with a tall house in the centre, &c. The unsightliness of the common plan will be seen by contrasting the picturesque cities of York or Lincoln with the formal and uninteresting appearance of Bath or Cheltenham, or they may be seen side by side in the old town of Hastings and the modern Eversfield, with the adjoining triumphal-arched town of St. Leonards. From this cause, London, though the

largest, is probably the least picturesque city in Europe. Lord Beaconsfield, in his "Tancred," has ably contrasted the old part of London with the new, and has pointed out the absence of all interest of character in the modern portions. Strange that he should have been able to see so clearly that which professors of the art have not only been blind to, but are continually helping to increase.

If the building is proposed to be placed by the side of a public road, it would be desirable to erect the principal front facing the south-east or south-west as nearly as possible. The principal front, therefore, can only in certain situations be parallel to the public road, but the preference should be given to the south-east. The complete drainage of a house is a point of the utmost importance, as upon it mainly depends the health and comfort of its inmates—and not only is it requisite that the drainage be perfect; but it must be as little liable as possible to get out of order, and when disturbed for the purpose of cleaning, should be capable of reinstatement with the materials at first used. The most essential points to be attended to in the drainage of buildings generally, where main sewers are formed, are the following:—Assuming in this plate that the main sewer is constructed in the front or principal road—and we desire to convey all our soil, waste water, &c., into it. On the block plan in Plate III., upon which are shown the grounds, buildings, &c., mark the most accessible places for fixing the tank, gulleys, traps, siphons, &c.; and then upon a skeleton block-plan and section, Plate II.; show the principal pipes for the conveyance of water to the tank, and the waste and soil drains, into the principal sewer, with the necessary falls, traps, and gulleys required.

Soilage-drains are sufficiently large for the passage of the soil and water when their diameter is 6 inches. They should have a fall of not less than 6 inches in every 100 feet, and more where possible. They should be made water-tight in order to prevent the liquid portions of the soilage from escaping and so leaving the solid matters in the drain. The waste water passed through should be amply sufficient to carry the soilage onward. To prevent the foul air generated in, or returning by the drains, the waste pipe should be double-trapped by a P-trap under the sink where the waste water enters, and by a gulley trap short of the inlet to the drain.

It is becoming the custom now in large towns to keep the drains conveying the surface-water and those from roofs separate from those used for soil-pipes, sink, and bath wastes, &c., the latter only being taken to the sewer, whilst the former is discharged into the nearest water-course or river, as circumstances permit; a duplicate system of drainage in fact being adopted. If, however, it is considered desirable to store the rain-water for use, it should be taken to a specially-constructed tank, as shown on Plate II., and described on p. 9. The pipes used should be of the best salt-glazed stoneware, with the joints made in Portland cement. It is also a good plan to bed these pipes in concrete, and then, after they have been tested and found to be water-tight, to cover them with another layer of concrete.

The house-drains should be laid in straight lines (all curves being avoided where possible), the various branches from water-closets, sink, and bath-wastes, &c., being each taken direct to a man-hole or inspection chamber, constructed in some convenient place in the

rear of the house, from which the main drain may be taken direct to the sewer. A similar man-hole or inspection chamber should be constructed in front of the house, upon the line of the main drain; by this arrangement, in the event of any stoppage occurring, the position and nature of same can be readily ascertained. A plan and section of this inspection chamber is given on Plate XIII.; it should be built in stock bricks in cement, upon a bed of concrete at least 6 inches thick, the bottom and sides, to a height of 2 feet, being finished in trowelled cement. Where the drain passes through inspection chamber the ordinary pipes are discarded, and half-round white-glazed channel-pipes are used instead (and for the branches also); the top of chamber is covered with a 4-inch tooled York stone, with a perforation in centre, upon which is placed an iron man-hole cover, Fig. 2, Plate XIII., to allow of inspection. Where the depth of drain is more than 4 feet from surface, wrought-iron steps should be fixed at sides of chamber. The inspection chamber in front of house should also have an interceptor-trap, as shown at A, Fig. 1, Plate XIII., inserted in the line of drain nearest to main sewer, to cut off any danger of sewer-gas entering from same. The upper limb of this interceptor shows what is called the flushing-arm, for flushing that portion of the main drain lying between the sewer and inspection chamber; it is also recommended to introduce fresh air into this inspection chamber by means of a short length of drain-pipe connected thereto at one end, as shown at B, Fig. 1, Plate XIII., the other end being taken to some convenient spot, from whence a galvanized iron pipe, at least 4 inches in diameter, should be taken to a height of 6

feet (fitted against a wall if possible), finished at top with a galvanized iron air inlet with a mica valve-flap, Fig. 3, Plate XIII.

At the highest point of the main drain and connected thereto, should be fixed a ventilating-pipe of galvanized iron, not less than 4 inches in diameter, carried up the wall of main building (well away from any windows) at least three feet above the eaves of roof, and surmounted with either a ventilating-cowl or a wire grating.

All drains should be laid outside the house or outbuildings wherever possible.

The rain-water pipes, wastes from baths, lavatories, sinks, &c., should not be connected directly with the drains, but should discharge at their feet in the open air, over a trap or gully, such as that shown on Fig. 4, Plate XIII. Soil-pipes, which should be of stout lead or galvanized iron with caulked joints, should be fixed externally (not internally), and be carried up to form ventilating-pipes in the manner previously described.

Supply of Water.

The arrangements for distributing a supply of water over the different parts of a building will depend very materially on the nature of the supply, whether constant or intermittent. The most common method of supply is from water-works, by pipes which communicate with private cisterns, into which the water is turned at stated intervals.

A cistern in a dwelling-house is always more or less an evil; it takes up a great deal of space, costs a great deal of money in the first instance, and often causes

inconvenience from leakage, from the bursting of the service pipes in frosty weather, and from the liability of self-acting cocks to get out of order. The common material for the cistern itself is stout galvanized iron; but slate cisterns are also occasionally used. The service or feed-pipe for a cistern, in the case of an intermittent supply, must be sufficiently large to allow of its filling during the time the water is turned on from the main. The flow of water into the cistern is regulated by a ball-cock, so called from its being opened and shut by a lever with a copper or zinc ball which floats on the surface of the water. The service pipes to the different parts of the building are laid into the bottom of the cistern, but should not come within an inch of the actual bottom, in order that the sediment, which is always deposited in a greater or less degree, may not be disturbed: the mouth of each pipe should be covered by a rose, to prevent any foreign substance being washed into the pipes and choking the taps. To afford a ready means of clearing out the cistern, a waste-pipe is inserted quite at the bottom, sufficiently large to draw off the whole contents in a short time when required; into the side of the cistern is fitted a short length of lead pipe, called a "warning pipe," to carry off any water when from any disarrangement in the working of the ball-cock the water continues running after the cistern is full. To insure proper attention to this warning pipe, it is usual for the end of it to discharge in the open air where it can be easily seen.

Where the supply of water is constant, instead of being intermittent, private cisterns may be altogether dispensed with; the main pipes not being required to

discharge a large quantity of water in a short time, may be of smaller bore, and consequently cheaper, and a considerable length of pipe is saved, as the water can be laid on directly to the several taps, instead of having to be taken up to the cistern and then brought back again. The constant flow of water through the pipes also much diminishes the risk of their bursting in frosty weather from freezing of their contents, when there is not a regular supply of water from the mains of water works, if any, as it frequently occurs. In new localities, wells are sunk, and the water raised by means of pumps, and conveyed by pipes to its required destination; and as rain-water is considered the purest of all water, it may be considered desirable to construct a filtering tank for its reception; and where there is a want of wholesome water, a tank might be constructed large enough to receive the rain-water from the roofs of a number of houses. This would insure a constant supply of soft and pure water for all domestic purposes.

The same would apply where there is no complete system of sewerage; a large manure tank might be constructed.

It is calculated that the average quantity of water which falls on a square yard of surface in Britain, in a year, amounts to about 120 gallons, which, for a building containing 100 square yards of roof, gives 12,000 gallons, an ample quantity for all purposes. Rain-water tanks are generally constructed in the following manner:—The ground being excavated, the bottom is laid with one or two courses of bricks, upon which two or three courses of tiles are laid in cement, and the sides and ends are formed with brickwork in cement. And the whole is then rendered with cement about an

inch in thickness. The top is either domed or covered with a flat stone. To filter water into a tank of this kind a small well or cistern is constructed, the bottom of which is perforated to admit the water, upon which the charcoal is laid, and then covered over with another perforated plate, as shown and described on Plate XIV.; a pump is then applied to the smaller cistern or filter for the supply. This, as will be perceived on inspection, would admit of ready cleaning, as the filter could at any time be lifted out. Plate XIV., Fig. 1, is a section of the rain-water tank; H the cistern; A the stone cover to the same; E E the portion for the filtered water; F filtering medium; C C the perforated portion for allowing the water to force itself through the filtering medium F; J rod for lifting the filters out of cistern when it requires cleaning; C the supply pipe; D waste ditto. Fig. 2 is a plan of the same tank; A cistern; B slate or earthenware filter. A modification of this arrangement may be adopted for smaller buildings, and a bucket may be applied for dipping the water from the filter.

CHAPTER II.

BRICKLAYER.

Our drainage, water supply, &c., having been considered as far as relates to our design, perhaps the next consideration would be for the erection of the carcass of the building, and probably we cannot do better than commence with the bricklayer.* The business of a bricklayer consists in the execution of all kinds of work in which brick is the principal material; and in London it usually includes paving with bricks or tiles. Where undressed stone is much used as a building material, the bricklayer occasionally executes this kind of work also; and in the country the business of the plasterer is sometimes connected with the above-named branches. And here, perhaps, we cannot do better than give the list of tools required, and the classification of them.

The tools of the bricklayer are—the *trowel*, to take up and spread the mortar, and to cut bricks to the requisite size; the *brick-axe* for shaping them to the required bevel; the *tin-saw* for making incisions in them to be cut with the *axe*; and a *rubbing-stone* to rub the bricks smooth after being roughly axed into shape. The *jointer* and the *jointing-rule* are used for running the centres of the mortar joints; the *raker* for raking out the joints of old brickwork, previous to repointing; the *hammer* for cutting chases and splays; the *banker*, which is a piece of timber about six feet long, raised on supports to a convenient height, to form a table on

* Consult Mr. E. Dobson's four volumes in this series. I. "Art of Building," No. 22; II. "Bricks and Tiles," No. 23; III. "Masonry and Stonecutting," No. 25; and IV. "Foundations," No. 44.

which to cut the bricks to any gauge for which moulds and bevels are required. The *crow-bar*, *pick-axe*, and *shovel* are used in digging out the foundation; and the *rammer* in punning the ground round the footings, and in rendering the foundation firm where it is soft, by beating or ramming.

To set out the work and keep it true, the bricklayer uses the *square*, the *level*, and the *plumb-rule*. For circular work he uses *templets** and *battering-rules; lines* and *pins* are used to lay the courses by, and *measuring-rods* to take dimensions when brickwork has to be carried up in conjunction with stonework; the height of each course must be marked on a *gauge-rod*, that the joints of each may coincide.

The bricklayer is supplied with bricks and mortar by a labourer, who carries them in a *hod;* the labourer also makes the mortar, and builds and strikes the scaffolding. The bricklayer's scaffold is constructed with *standards*, *ledgers*, and *putlogs*. The standards are fir poles, from forty to fifty feet long, and six or seven inches in diameter at the butt ends, which are firmly bedded in the ground. When one pole is not sufficiently long, two are lashed together, top and butt, the lashings being tightened with wedges. The ledgers are horizontal poles, placed parallel to the walls and lashed to the standard for the support of the putlogs. The putlogs are cross pieces, usually made of birch, and about six feet long, one end resting in the wall, the other on a ledger. On the putlogs are placed the scaffold boards, which are stout boards hooped with iron at the ends, to prevent them from splitting.

* The templet should be carefully cut to the form of the work to be executed. For description of the tools used, see Weale's "Technical Dictionary," No. 36 of this series.

A bricklayer and his labourer will lay in a day about 1000 bricks, or about two cubic yards.

The tools required for tiling are the *lathing-hammer*, with two gauge marks on it, one at 7 and the other at $7\frac{1}{2}$ inches; the iron *lathing-staff*, to clinch the nails; the *trowel*, longer and narrower than that used for brick-work; the *bosse*, for holding mortar and tiles, with an iron hook to hang it to the tiles or to a ladder; and the *striker*, a piece of lath about 10 inches long, for clearing off the superfluous mortar at the foot of the tiles.

Brickwork is measured and valued * by the rod or by the cubic yard, the price including the erection and use of scaffolding, but not centering to arches, which is an extra charge. Bricknogging, pavings, and facings by the superficial yard. Digging and steining of wells and cesspools by the foot in depth according to size, the price increasing with the depth. Plain tiling and pantiling are valued per square of 100 feet superficial.

A journeyman bricklayer receives from $9\frac{1}{2}d.$ to $10\frac{1}{2}d.$ and a labourer $6\frac{1}{2}d.$ per hour.

The following memoranda may be useful :—

WEIGHTS OF DIFFERENT KINDS OF EARTH.

$15\frac{1}{2}$	cubic feet of	chalk	weigh . . .	one ton.
18	,,	clay	,, . . .	one ton each.
18	,,	night soil	,, . . .	
19	,,	gravel	,, . . .	
21	,,	sand	,, . . .	

Twenty-seven cubic feet, or 1 cubic yard, is called a single load, and 2 cubic yards a double load.

A measure of lime is 27 cubic feet, and contains 21 strike bushels.

A bricklayer's hod measures 1 ft. 4 in. × 9 × 9, and contains 20 bricks.

* See Mr. A. C. Beaton's "Measurements and Quantities," in this series.

A rod of brickwork measures 16½ ft. square, 1½ brick thick (*which is called the reduced or standard thickness*) or 272 ft. 3 in. superficial or 306 cubic feet, or 11½ cubic yards.

A rod of brickwork, laid four courses to a foot in height, requires 4,353 stock bricks.

Ditto 11½ inches to four courses, 4,533 stock bricks.

These calculations are made without allowing for waste, which is necessary, because the space occupied by flues, bond-timber, &c., and for which no deduction is made, more than compensates for any waste; and in building dwelling-houses, 4,540 stocks to a rod is sufficient.

If laid dry, 5,370 to the rod.

4,900 ditto in wells and circular cesspools.

A rod of brickwork, laid 4 courses to gauge 12 in., contains 235 cubic feet of bricks and 71 cubic feet of mortar, and weighs about 15 tons.

A rod of brickwork requires 1½ cubic yards of chalk lime, and 3 single loads of sand, or 1 cubic yard of stone lime, and 3½ loads of sand or 36 bushels of cement, and an equal quantity of sharp sand.

A cubic yard of mortar requires 9 bushels of lime and 1 load of sand.

Lime and sand, and likewise cement and sand, lose one-third of their bulk when made into mortar.

The proportion of mortar or cement, when made up, to the lime or cement and sand before made up, is as 2 to 3.

Lime or cement and sand to make mortar require as much water as is equal to one-third of their bulk.

A cubic yard of concrete requires 34 cubic feet of material; or if the gravel is to the lime as 6 to 1, a concrete will require 1·1 cubic yard of gravel and sand, and 3 bushels of lime.

Facing requires 7 bricks per foot superficial.

Gauged arches 10 ditto, ditto.

Bricknogging, per yard superficial, requires 30 bricks on edge, or 45 laid flat.

PAVING.

Stock bricks laid flat require	36	per yard superficial.	
Paving ditto on edge	„ 52	„	
Paving ditto laid flat	„ 36	„	
Ditto on edge	„ 82	„	
Dutch clinkers	„ 140	„	
12-inch paving tiles	„ 9	„	
10-inch ditto	„ 13	„	

TILING.

Description.	Gauge in Inches.	No. required per Square.
With pantiles	12	150
Ditto	11	164
Ditto	10	180
With plain tiles	4	600
Ditto	$3\frac{1}{2}$	700
Ditto	3	800

N.B.—A square of pantiling requires one bundle of laths, and 125 sixpenny nails; and plain tiling, one bundle laths, one peck of tile pins, and 3 hods of mortar.

A TABLE

Of the Sizes and Weights of various Articles employed in Building.

Description.	Length.	Breadth.	Thickness.	Weight.
	ft. in.	ft. in.	ft. in.	lbs. ozs.
Stock-bricks . . . . each	0 $8\frac{3}{4}$	0 $4\frac{1}{4}$	0 $2\frac{1}{2}$	5 0
Paving ditto . . . . „	0 9	0 $4\frac{1}{2}$	0 $1\frac{3}{4}$	4 0
Dutch clinkers . . . „	0 $6\frac{1}{4}$	0 3	0 $1\frac{1}{2}$	1 8
12-inch paving-tiles . „	0 $11\frac{3}{4}$	0 $11\frac{3}{4}$	0 $1\frac{1}{2}$	13 0
10-inch ditto . „	0 $9\frac{3}{4}$	0 $9\frac{3}{4}$	0 1	8 9
Plain tiles . . . . „	0 $10\frac{1}{2}$	0 $6\frac{1}{2}$	0 $0\frac{5}{8}$	2 5
Pantile laths, per 10-feet bundle	120 0	0 $1\frac{1}{2}$	0 1	4 6
Ditto, 12-feet ditto . . . N.B.—A bundle contains twelve laths.	144 0	0 $1\frac{1}{2}$	0 1	5 0
Plain tile laths, per bundle . Thirty bundles of laths make a load.	500 0	0 1	0 $0\frac{1}{2}$	3 0

To ascertain the quantity of brickwork* contained in a well, take the diameter, allowing the thickness on one side, three times of which, and one-seventh, will be the circumference. This should be multiplied by the depth, and the contents brought into brick and half work.

To find what quantity of water a well will hold, multiply half the circumference by half the diameter; this should be multiplied by the depth, and will give the number of cubic feet which will contain 6 gallons and 1 pint each.

Having explained the various tools and principal materials used in the trade of a bricklayer, we would impress upon the young artisan to give some attention to geometrical drawing, without which he will never be enabled to read or comprehend the design he may be entrusted with to execute. For, even in the simple turning of an arch over a centre already fixed for him, unless he knows that every brick should radiate to a centre and knows how to find that centre, he will never be certain of making sound work to his arch. We have endeavoured to show this in two diagrams shown on Plate XVI., Figs. 4 and 5. Let 1—2 be the opening or span of the segment of an arch; E F the rise; stretch a line, or apply a straight edge, from 2 to F, and mark the centre C; apply the square, and the point where it intersects the centre of the rise B F will be the centre for the arch; consequently, B will be the converging point for all the bricks on that arch. Fig. 5 merely exemplifies the same principle applied to the ellipse.

* Much time will be saved by using the *Slide-rule* in making these calculations. See "The Slide Rule, and its Use," by Mr. C. Hoare, in this series.

CHAPTER III.

CARPENTER.

THE business of the carpenter consists in framing timber together for the construction of *floors, partitions, roofs, &c.**

The carpenter's principal tools are the *adze,* the *saw,* and the *chisel,* to which may be added, the *chalk-line, plumb-rule, level,* and *square.* The work of the carpenter does not require the use of the *plane,* which is one of the chief tools of the joiner; and this forms the principal distinction between these two trades, the carpenter being engaged in the rough frame-work, and the joiner on the finishings and decorations of buildings.

Probably the first occupation a carpenter will have in a building is the preparation and laying of bond-timber, making and fixing of centres, &c. Bond-timber and wood-bricks were formerly used as the only means for providing against irregular settlement in the brick-work. There is, however, a great objection to the use of timber in the construction of a wall, as it shrinks away from the rest of the work, and often endangers its stability by rotting. Instead of bond-timbers, hoop-iron bond is now very generally used. This is formed of iron hooping tarred, to protect the iron from contact with the mortar, and laid in the thickness of the mortar joint. This forms a very permanent longitudinal tie, and has all the advantages, with none of the disadvantages, of the bond-timbers.

* "Carpentry and Joinery," founded on Robison and Tredgold, No. 182; and "The Construction of Roofs of Wood and Iron," No. 228 of this series.

Floors.

The assemblage of timbers forming any naked flooring may be either single or double. Single flooring is formed with joists reaching from wall to wall, where they rest on plates of timber, built into the brickwork, and called wall-plates. The floor-boards are nailed over the upper edges of the joists, whose lower edges receive the lathing and plastering of the ceilings. Double floors are constructed with stout binding joists, a few feet apart, reaching from wall to wall, and supporting ceiling joists, which carry the ceiling, and bridging joists, on which are nailed the floor-boards. In double framed flooring, the binders, instead of resting on the walls, are supported on *girders*. Single flooring is in many respects inferior to double flooring, being liable to sag or deflect, so as to make the floors concave; and the situation of the joists occasions injury to the ceilings, and likewise shakes the walls. This may be prevented in single floors by herring-bone, trussing them, and introducing an iron rod from wall-plate to wall-plate, as shown and described on Plate XIX., Figs. 1, 2, 3, and 4. Fig. 5 shows the method of applying sound boarding puggings, &c., to prevent any sound passing between the upper and lower floors. In double floors, the stiffness of the binders and girders prevents both deflection and vibration, and the floors and ceilings hold their lines, that is, retain their intended form much better than in single flooring.

If it were not for the increased expense, it would be much better for all the joists of a single floor to be laid on a plate supported by projecting corbels, which prevents the wall being crippled in any way by the in-

sertion of the joists. The plates of basement floors are best supported on small piers carried up from the footings. This is an important point to be attended to, as the introduction of timbers into a wall is nowhere likely to be productive of such injurious effects as at the foundations, where from damp and imperfect ventilation all woodwork is liable to speedy decay.

Partitions.

The partitions forming the interior divisions of a building may be either solid walling of brick or stone, or they may be constructed entirely of timber, or they may be frames of timber, filled in with masonry or brickwork. It would always be best for durability, and security against fire, to make the partitions of solid walling; but this is not always practicable; and in the erection of houses they are generally made of timber.

The principles to be kept in view, in the construction of framed partitions, are very simple. Care must be taken to avoid any cross strain, and they should not in any way depend for support upon subordinate parts of the construction, but should form a portion of the main carcass of the building, and quite independent of the floors, which should not support, but be supported by them.

When a partition extends through two or more stories of a building, it should be as much as possible a continuous piece of framing, with strong sills, at proper heights, to support the floor-joists.

Where openings occur, as for folding-doors, or where a partition rests on the ends of the sill only, it should

be strongly trussed, so that it is as incapable of settlement as the walls themselves.

From want of attention to these points, we frequently see in dwelling-houses floors which have sunk into curved lines, doors out of square, cracked ceilings and broken cornices, and gutters that only serve to conduct the roof-water to the interior of the building, to the injury of ceilings and walls, and the great discomfort of the inmates.

Roofing.

In roofs of the ordinary construction, the roof-covering is laid upon rafters, supported by horizontal purlins, which rest on upright trusses, or frames of timber, placed on the walls at regular distances from each other. Upon the framing of the trusses depends the stability of the roof; the arrangement of the rafters and purlins being subordinate matters of detail. The timbering of a roof may be compared to that of a double-framed floor; the trusses of the former corresponding to the girders of the latter, the purlins to the binders, and the rafters to the joists.

Timber roofs may be divided into two heads:—

First. Those which exert merely a vertical pressure on the walls on which they rest.

Secondly. Those in which advantage is taken of the strength of the walls to resist a side thrust, as in many of the gothic open-timbered roofs.

Trussed roofs exerting no side thrust on the walls consist essentially of a pair of principals, or principal rafters, and a horizontal tie-beam, and in large roofs these are connected and strengthened by king and queen posts and struts.

The collar beam roof is the most simple truss, in which the tie is above the bottom of the feet of the principal, which is often done in small roofs for the sake of obtaining height. In this roof the feet of both common and principal rest on a wall-plate, and the tie is called a collar. The purlins rest on the collar, and the common rafters butt against a ridge running along the top of the roof. This kind of truss is only suited for very small spans, as there is a cross strain on that part of the principal below the collar which is rendered harmless in a small space by the extra strength of the principal; but which, in a larger one, would be very likely to thrust out the walls.

In roofs of larger spans the tie-beams are placed below the feet of the principals, which are tenoned into and bolted or strapped to them. To keep the beam from sagging, or bending by its own weight, it is suspended from the head of the principal by a king-post of wood or iron. The lower part of the king-post affords abutments for struts, supporting the principals immediately under the purlins, so that no cross-strain is exerted on any of the timbers in the truss, but they all act in the direction of their length, the principals and struts being subjected to compression, and the king-posts and tie-beams to tension. The common rafters butt on a pole plate, the tie-beams resting either on a continuous wall-plate, or on short templates of wood or stone. Where the span is considerable, the tie-beam is supported at additional points by suspension pieces called queen posts, from the bottom of which spring additional struts; and by extending this principle *ad infinitum* we might construct a roof of any span,

were it not that a practical limit is imposed by the nature of the materials.

Having in a cursory manner described the principles of framing, we will now endeavour to describe some of the principal joints made use of in framing. Timbers that have to be joined in the direction of their length, are what is termed scarfed together, that is, an oblique cut is made across the width of one piece at the end, proposed to be joined, and a corresponding one to the piece proposed to be added to it, with bird's-mouth bevels at each end and notches in the middle to admit of oak or iron wedges; these are then placed together and secured either by iron bolts or straps. The king-post is connected with the tie-beam by a tenon and mortice, and the post should be cut somewhat short, to give the power of screwing up the framing after the timber has become fully seasoned. The tie-beam may be suspended from the king-post either by a bolt or by a strap passed round the tie-beam, and secured by iron wedges or cotters passing through a hole in the king-post; this last is the more perfect, but at the same time the more expensive of the two methods.

The king-post is generally cut with joggles for the principal rafters and struts to abut against and frame into. The ends of the principal rafters and struts should be cut off as nearly square as possible, and tenoned into the joggles—otherwise when the timber shrinks, which it will more or less, the thrust is thrown upon the edge only, which splits or crushes under the pressure and causes settlement.

The wall-plates are halved and dove-tailed together, and the tie-beams cogged upon them, the purlins

bridged upon the principal rafters, and the common rafters notched upon the purlins. And it should be observed, as a general rule, all timbers should be notched down to those on which they rest, so as to prevent their being moved either lengthways or sideways. Where an upright post has to be fixed between two horizontal sills, as in the case of the uprights of a common framed partition, it is simply tenoned into them, and the tenons secured with oak pins driven through the cheeks of the mortice.

The carpenter requires considerable bodily strength for the handling of the timbers on which he has to work; he should have a knowledge of mechanics, that he may understand the nature of the strains and thrusts to which his work is exposed, and the best method of preventing or resisting them; and he should have such a knowledge of working drawings as will enable him, from the sketches of the architect, to set out the lines for every description of work for centering, framing, &c., that may be entrusted to him for execution.

In measuring carpenter's work, the tenons are included in the length of the timber. This is not the case in joiner's, in which they are allowed for in the price. Carpenter's work is generally measured by the square of 100 feet, and the cubical contents of every square taken out; and nothing is to be deducted for chimneys, as the extra thickness of the trimmers will make up the deficiency, and in a quarter partition the braces and extra thickness of the door-posts will make up for the opening, but the head and sill must be taken separate; and if the joists or quarterings in roofs or partitions are 13 inches asunder, one-twentieth of the quantity found is to be taken off—but if placed within 11 inches, one-

twentieth must be added. And in measuring the work for labour, only take the extreme verge, including the bearings, one way, and make no deductions for well-holes, chimney-breasts, doorways, &c. The timber to be collected the full length and size, and charged as "cube fir," without labour. The following tables should be constantly borne in mind by the young carpenter :—

Lineal or running measure contains 12 inches in 1 foot, 3 feet in 1 yard, 2 yards 1 fathom, and 1,760 yards or 5,280 feet in one mile.

Superficial measure contains 144 square inches in 1 foot, 9 feet in 1 yard, and 100 feet in 1 square of flooring, roofing, partitioning, &c. ; 272¼ feet in 1 rod or pole, and 160 poles in 4,840 yards, or 43,560 feet in 1 acre.

Cubic measure comprises the length, breadth, and thickness, and contains 1,728 inches in 1 cubic foot, 27 cubic feet in one cubic yard, 282 cubic inches in 1 gallon, and 6 gallons and 1 pint in each cubic foot.

To measure round timber, multiply the mean or quarter girt by itself, and that product by the length by cross multiplication, and the cubical quantity will be ascertained. For instance: suppose a piece of timber to girt 6 feet, one-quarter of this will be 1 foot 6 inches, which, multiplied by 1 foot 6 inches, will give 2 feet 3 inches superficial, which, multiplied by the length (say 20 feet), will give the contents—45 feet cube; and in the same way for any other size.

A TABLE

Of quantities of Timber each making One Load.

50 cubic feet of square timber.	600 sq. feet of 1-inch planking
40 ditto of round or rough.	30 12-feet 3-inch deals.
150 sq. feet of 4-inch planking.	26 14-feet ditto ditto.
170 sq. feet of 3½-inch ditto.	18 20-feet ditto ditto.
200 sq. feet of 3-inch ditto.	25 12-feet 3-inch plank
240 sq. feet of 2½-inch ditto.	21 14-feet ditto ditto.
300 sq. feet of 2-inch ditto.	18 16-feet ditto ditto.
400 sq. feet of 1½-inch ditto.	15 20-feet ditto ditto.

The following quantities of Material will each, on an average, weigh One Ton :—

39 cubic feet of oak timber.	35 12-feet 2½-inch deals.
50 ditto of fir ,,	30 ditto 3-inch ditto.
60 ditto of elm ,,	46 12-feet 2½-inch batten.
45 feet of ash ,,	38 ditto 3-inch ditto.
50 feet of beech ,,	

The number of Cubic Feet in every Square of Flooring, Roofing, or Quarter Partitions of the following different dimensions, the timbers one foot apart, and one extra one allowed in a width of 15 *feet.*

Roofs and Quarter Partitions.

inches.	cubic ft.	in.	inches.	cubic ft.	in.
2 by 2½	3	3½	3 by 4½	8	8
2 ,, 3	4	0	4 ,, 2½	6	7
3 ,, 2½	4	11	4 ,, 4	10	10
3 ,, 3	5	9	4 ,, 4½	12	6
3 ,, 3½	6	5	4 ,, 5	13	2
3 ,, 4	7	8			

Naked Floor without Girder.

inches.	cubic ft.	in.	inches.	cubic ft.	in.
5 by 2½	8	3	9 by 2½	14	9
5 ,, 3	9	7	9 ,, 3	17	3
6 ,, 2½	9	9	10 ,, 2½	16	7
6 ,, 3	11	6	10 ,, 3	19	0
7 ,, 2½	11	5	11 ,, 2½	18	5
7 ,, 3	13	4	11 ,, 3	20	9
8 ,, 2½	13	1	12 ,, 2½	19	0
8 ,, 3	15	4	12 ,, 3	23	0

The above tables of different scantlings will be found

very useful to those who are unacquainted with taking, squaring, and cubing dimensions; as also to such as have to make an estimate in a hurry, as they are the common dimensions of fir scantling for joists, rafters, and quarters for roofs and partitions, of second, third, and fourth-rate houses: but we would advise the young carpenter to take the dimensions of the timber required for any stated work, and square and cube them himself.*

CHAPTER IV.

MASON.

The business of the mason consists in working the stones to be used in a building to their shape and setting them in their places. The works connected with the trade of the mason are those of the stone-cutter, who hews and cuts large stones roughly into shape preparatory to their being worked by the mason, and of the carver, who executes the ornamental portions of the stone-work of a building, as enriched cornices, capitals, &c. Where the value of stone is considerable it is sent from the quarry to the building in large blocks, and cut into slabs and scantlings of the required size with a stone-mason's saw, which differs from that used in any other trade in having no teeth. It is a long thin plate of steel, slightly jagged on the bottom edge, and fixed in a frame, and, being drawn backwards and forwards in a horizontal position, cuts the stone by its own weight. To facilitate the operation a heap of

* See "Quantities and Measurements," by Alfred Charles Beaton, and "The Slide Rule and its Uses," by Charles Hoare, both in this Series.

sharp sand is placed on an inclined plane over the stone, and water allowed to trickle through it so as to wash the sand into the saw cut. Of late years machinery worked by steam-power has been used for sawing marble into slabs as well as stone to a very great extent, and has almost entirely superseded manual labour in this part of the manufacturing of chimney-pieces.

Some freestones, as Bath stone, are so soft as to be easily cut with a toothed saw worked backwards and forwards by two persons. The harder kinds of stones, as granites and gritstones, are brought roughly into shape at the quarry, with an axe or *scappling* hammer, and are then said to be *scappled.** The tools used by the mason for cutting stone consist of the *mallet* and chisels of various sizes. The mason's mallet differs from that used by any other artisan, being similar to a dome in *contour,* excepting a portion of the broadest part, which is rather cylindrical; the handle is short, being only sufficiently long to enable it to be firmly grasped. In London the tools used to break the faces of the stone are the *point,* which is the smallest description of *chisel,* being never more than a quarter of an inch broad on the cutting edge; *the inch tool;* the *boaster,* which is two inches wide, and the *broad tool,* of which the cutting edge is three and a-half inches wide. The tools used in working mouldings, and in carving, are of various sizes according to the nature of the work. Besides the above cutting tools, the mason uses the *banker* or bench, in which he places his stone for convenience of working, and straight-edges, squares,

* Reduced to a straight surface without being worked smooth (See "Technical Dictionary.")

levels, and templets, for marking the shapes of the blocks, and for trying the surfaces as the work proceeds. Any angle greater or less than a right angle is called a bevel angle, and a bevel is formed by nailing two straight-edges together at the required angle; a bevel square is a *square* with a shifting back, which can be set to any required bevel. A templet is sometimes called a mould, which moulds are commonly made of sheet zinc carefully cut to the profile of the mouldings with shears and files. For setting his work in place the mason uses the trowel, lines, and pins, the square and level, and plumb, and battering rules for adjusting the faces of upright and battering walls.

The mason's scaffold is double, that is, formed with two rows of standards, so as to be totally independent of the walls for support, as putlog holes are inadmissible in masonry.

Of late years the construction of scaffolds with round poles lashed together with cords, has been superseded in large works by a system of scaffolding of square timbers connected together by bolts and dog-irons. The hoisting of the materials is performed from these scaffolds by means of a travelling crane, which consists of a double travelling carriage running on a tramway formed on straight sills laid on the top of two parallel rows of standards. The crab winch is placed on the upper carriage, and by means of the double motion of the two carriages can be brought with great ease and precision over any part of the work lying between the two rows of standards.

The facilities which are afforded by these scaffolds and travelling cranes for moving heavy weights over large areas have led to their extensive adoption, not

only in the erection of buildings, but on landing wharfs, masons' and iron-founders' yards, and similar situations, where a great saving of time and labour is effected by their use. Scaffolding of square timbers appears to have been little used in England before 1837, when Messrs. Cubitt, of Gray's Inn Road, applied it to the erection of the entrance gateway of the Euston Station of the North-Western Railway. And it was used on a very large scale at the new Houses of Parliament, and the Nelson Column,—where it was carried up in perfect safety to the height of 180 feet. Since then it has been very generally used in large works.

The movable derrick crane is also much used in setting mason's work. It consists of a vertical post supported by two timber back-stays, and a long movable jib or derrick hinged against the post below the gearing. By means of a chain passing from a barrel over a pulley at the top of the post, the derrick can be hoisted to an almost vertical, or lowered to nearly a horizontal position, thus enabling it to command every part of the area of a circle of a radius nearly equal to the length of the derrick. This gives it a great advantage over the old gibbet-crane, which only commands a circle of a fixed radius, and the use of which entails great loss of time from its constantly requiring to be shifted as the work proceeds.

Derrick cranes appear to have been first introduced at Glasgow, in 1831, by Mr. York, since which time their original construction has been greatly improved upon, and they are now very extensively used.

In hoisting blocks of stone they are attached to the tackle by means of a simple contrivance called a *lewis*, which consists of the following arrangement:—A taper-

ing hole is cut in the upper surface of the stone to be raised; the two side pieces of the lewis are inserted and placed against the sides of the holes (which being made in the form of a dovetail, and the aperture in the stone made to correspond), a centre parallel piece is then dropped in and secured in its place by a strong pin passing through all three pieces, and the stone may then be safely hoisted, as it is impossible for the lewis to be drawn out of the hole. By means of a lewis, slightly different in form from that just described, stone can be lowered and set under water without difficulty, the lewis being disengaged by means of a line attached to the parallel piece, the removal of which allows the other to be drawn out of the mortice.

In stone-cutting the workman forms as many plane faces as may be necessary for bringing the stone into the required shape with the least waste of material and labour, and on the plane surface, so formed, applies the moulds to which the stone is to be worked.

To form a plane surface the mason first knocks off the superfluous stone along one edge of the block until it coincides with a straight-edge throughout its whole length—this is called a *chisel draught*. Another chisel draught is then made along one of the adjacent edges, and the ends of the two are connected by another draught. A fourth draught is then sunk across the last, which gives another angle point in the same plane with the other draughts, and the stone is then knocked off between the outside draughts until a straight-edge coincides with its surface in every part.

To form cylindrical or moulded surfaces, curved in one direction only, the workman sinks two parallel draughts at the opposite ends of the stone, to be worked until they coincide with a mould cut to the required

shape, and afterwards works off the stone between these draughts by a straight-edge applied at right angles to them.

The formation of conical or spherical surfaces is much less simple, and requires a knowledge of the scientific operations of stone-cutting, a description of which would be unsuited to the elementary character of these pages. The reader who wishes to pursue the subject is therefore referred to the writer's volume (25) of this series on Masonry and Stone-cutting, where he will find the required information.

The finely grained stones are usually brought to a smooth surface, and rubbed with sand to produce a perfectly even surface.

In working soft stones the surface is brought to a smooth face with a drag, which is a plate of steel, indented on the edge like the teeth of a saw, to take off the marks of the tools employed in shaping it. The harder and more coarsely grained stones are generally tooled; that is, the marks of the chisel are left on their face. If the furrows left by the chisel are disposed in regular order, the work is said to be *fair-tooled;* but if otherwise, it may be *random-tooled,* or *chiselled,* or *boasted,* or *pointed.* If the stones project beyond the points, the work is said to be *rusticated* or reticulated.

Granite and gritstone are chiefly worked with the scappling hammer. In massive erections, where the stones are large, and effect is required, the fronts of the blocks are left quite rough, as they come out of the quarry, and the work is then said to be *quarry pitched.*

Many technical terms are used by quarry-men,* and

* See "Technical Dictionary of Terms used in Architecture, Building," &c.

others engaged in working stone; but they need not be inserted here, as they are mostly confined to particular localities, beyond which they are little known, or perhaps bear a different signification. When the mason requires to give the joints of his work greater security than is afforded by the weight of the stone and the adhesion of the mortar, he makes use of *joggles, dowels,* and *cramps.* Stones are said to be joggled when a projection is worked out on one stone to fit in a corresponding hole or groove in the other; but this occasions great labour and waste of stone. Dowels are chiefly made use of, which are hard pieces of stone cut to the required size, and let into corresponding mortices in the two stones to be joined together.

Dowels may be pins of wood, metal, or stone, used to secure the joints of stone-work in exposed situations, as copings, pinnacles, &c. The best material is copper; but the expense of this metal causes it to be seldom used. If iron be made use of it should be thoroughly tarred, to prevent oxidation, or it will sooner or later burst or split the work it is intended to protect. Dowels are often secured in their places with lead poured in from above, through a small channel cut in the side of the joint for that purpose; but a good workman will eschew lead, which too often finds its way into bad work, and will prefer trusting to very close and workmanlike joints, carefully fitted dowels, and fine mortar. Dowels should be made tapering at one end, which ensures a better fit, and renders the setting of the stone more easy for the workman.

Iron cramps are used as fastenings on the tops of copings, and in similar situations; but they are not to be recommended, as they are very unsightly, and if they once become exposed to the action of the atmo-

sphere, are powerfully destructive agents. Cast iron is, however, less objectionable than wrought for this purpose.

In measuring mason's work, the cubic contents of the stone is taken as it comes to the *banker*, without deduction for subsequent waste. If fixed above 40 feet high, an extra price is allowed for hoisting. The labour in working the stone is charged by the superficial foot, according to the kind of work, as plain work, sunk work, moulded work, &c. Pavings, landings, &c., and all stones less than three inches thick, are charged by the superficial foot. Copings, curbs, window-sills, &c., are charged per lineal foot. Cramps, dowels, mortice holes, &c., are always charged separately.

A journeyman mason will receive from $9\frac{1}{2}d.$ to $10\frac{1}{4}d.$ per hour, and the labourer $6\frac{1}{2}d.$ per hour; but masons working piece-work, or at any work requiring particular skill, will often earn much more. The remuneration of a stone-carver is dependent on his talent, and the kind of work he is engaged upon.

The following table of the weights of the different kinds of stone will convey an idea of their relative hardness, and of the labour required to work them :—

TABLE

Of the Weights of different kinds of Stone.

13	cubic feet	of marble	weigh	one ton.
$13\frac{1}{2}$	,,	of granite	,,	,,
14	,,	of Purbeck stone	,,	,,
$14\frac{1}{2}$	,,	of Yorkshire stone	,,	,,
16	,,	of Derbyshire grit	,,	,,
$15\frac{1}{2}$	,,	of Portland stone	,,	,,
16	,,	of Bath stone.	,,	,,
58	feet superficial	of 3-inch York paving .	,,	,,
70	,,	of $2\frac{1}{2}$-inch ,, .	,,	,,

PLUMBER.

The work of the plumber chiefly consists in laying sheet lead on roofs, lining cisterns, laying on water to the different parts of a building, and fixing up pumps and water-closets. The plumber uses but few tools, and those are of a simple character, the greater number of them being similar to those used by other artificers, *hammers, mallets, planes, chisels, gouges, files*, &c. The principal tool peculiar to the trade of the plumber is the *bat*, which is made of beech. It is about eighteen inches long, and is used for dressing and flattening sheet lead. For soldering, the plumber also uses iron ladles of various sizes for melting solder, as well as lead, and *grozing-irons* for smoothing down the joints. The sheet-lead used by the plumber is either *cast* or *milled*, the former being generally cast by the plumber himself out of old lead taken in exchange, whilst the latter, which is cast lead flattened out between two rollers in a flatting mill, is purchased from the manufacturer. Sheet-lead is described, according to the weight per superficial foot, as 5 lb. lead, 6 lb. lead, &c.

Lead-pipes, if of large dimensions, are made of sheet-lead dressed round a wooden core and soldered up. Smaller pipes are cast in short lengths, of a thickness three or four times that of the intended pipe, and either drawn or rolled out to the proper thickness.

Soft-solder is used for uniting the joints of lead-work; it is made of equal parts of lead and tin, and is purchased of the manufacturer, by the plumber, at a price per lb., according to the state of the market.

Laying of Sheet-lead.

In order to secure lead-work from the injurious effect of contraction and expansion where exposed to the heat of the sun, the plumber is careful not to confine the metal by soldered joints, or otherwise. All sheet-lead should be laid with a slope sufficient to keep it dry; a fall of one inch in ten feet is sufficient for this purpose, if the boarding on which the lead is laid be perfectly even.

Flashings are pieces of lead turned down over the edges of other lead-work, which is turned up against a wall, and serve to keep the wet from finding its way between the wall and the lead. The most secure way of fixing them is to build them into the joints of the brickwork, but the common method is to insert them about an inch into the mortar joint, and to secure them with wall hooks and cement.

A very important part of the business of the plumber consists in fitting up cisterns, pumps, and water-closet apparatus, and in laying the different services and wastes connected with the same.

Plumber's work is paid for by the cwt.; milled-lead being rather more expensive than cast. Lead pipes are charged per foot lineal, according to size.

Pumps and water-closet apparatus are charged at so much each, according to description, as also basins, air-traps, washers and plugs, spindle valves, stop-cocks, ball-cocks, &c.

TABLE

Of the Weight of Lead Pipes per Yard.

Bore.	lbs.	ozs.	Bore.	lbs.	ozs.
½-inch	3	3	1¼-inch	11	0
¾-inch	5	7	1½-inch	14	0
1-inch	8	0	2-inch	21	0

The wages of a journeyman plumber are $10\frac{1}{2}d.$ per hour, and the plumber's mate receives $6\frac{1}{2}d.$ per hour.

ZINC-WORKER.

The use of sheet-lead has been to a certain extent superseded by the use of sheet-zinc, which, from its cheapness and lightness, is very extensively used for almost all purposes to which sheet-lead is applied. It is, however, a very inferior material, and not to be depended on. The laying of it is generally executed by the plumber, but the working of zinc, and manufacturing of it into gutters, rain water-pipes, chimney-cowls, and other articles, is practised as a distinct business.

SMITH AND IRON-FOUNDER.

The smith furnishes the various articles of wrought iron work used in a building, as pileshoes, straps, screw-bolts, dog-irons, chimney-bars, gratings, wrought-iron railing, and iron balustrades for staircases. Wrought-iron was formerly much used for many purposes, for which cast-iron is almost exclusively employed; the improvements effected in casting during the present century having made a great alteration in this respect. The operations of the iron-founder have been much improved since the middle of the last century, when the smelting of iron was carried on with wood charcoal, and the ores used were chiefly from the secondary strata, although the clay iron-stones of the coal-measures were occasionally used. The weald of Kent and Sussex contained many iron-works during the seventeenth century. The one formerly situated at Lamberhurst, near Tunbridge Wells, Sussex, is noted

as having furnished the cast-iron railing round St. Paul's Cathedral. The tilt hammers used in forging bar-iron were chiefly worked by water power. A large pool in Beeding Forest, near Horsham, Sussex, still retains the name of the Hammer Pond, and the former sites of many old forges in the Wealden district may still be traced by the heaps of cinders which yet remain here and there, and by the local name to which the works gave rise.

The introduction of smelting with pit-coal coke during the last century caused a complete revolution in the iron trade. The ores now chiefly used are the clay iron-stones of the coal measures, and the fuel pit-coal or coke.

Steam power is almost exclusively used for the production of the blast furnaces, and for working the forge hammers and rolling mills. For the production of wrought-iron in the ordinary manner, two distinct sets of processes are required: 1st, the extraction of the metal from the ore in the shape of cast-iron; 2nd, the conversion of cast-iron into malleable or bar-iron by remelting, puddling, and forging. The conversion of bar-iron into steel is effected by placing it in contact with powdered charcoal in a cementing furnace.

Cast-iron is produced by smelting the previously calcined ore in a blast furnace along with a certain quantity of limestone and coke; the former acts as a flux, while the combustion of the latter supplies the heat. The metal when fused sinks to the bottom, while the limestone and the impurities rise to the top, and are allowed to run off, forming slag or cinder. The melted metal is run off from the bottom of the furnace into moulds in the case of castings, and into furrows

made in a level bed of sand, when the metal is required for conversion into malleable iron; the bars thus produced being called *pigs*.

In the year 1827 it was discovered that by the use of heated air for the blast a great saving of fuel could be effected as compared with the cold blast process. The hot blast is now very extensively used, and has the double advantage of requiring less fuel to bring down an equal quantity of metal, and of enabling the manufacturer to use raw pit-coal instead of coke; so that a saving is effected both in the quantity and cost of the fuel.

For a considerable time after its introduction it was held in great disrepute; which, however, may be chiefly attributed to the inferior quality of ores used, the power of the hot blast in reducing the most refractory offering a great temptation to obtain a much larger product from the furnaces than was compatible with the good quality of the metal.

The use of the hot blast by firms of acknowledged character has greatly tended to remove the prejudice against it, and in many iron-works of high character nothing but the hot blast with pit-coal is used in the smelting furnaces, the use of coke being confined to the subsequent processes.

It may be laid down as a principle, that in architectural structures, at least where a proper margin of safety has been provided in determining the scantlings of either cast or wrought-iron to resist known stresses in construction, that it is practically unimportant at present (1895) to the architect whether the metals he specifies or employs be hot blast or cold blast.

The temperature of the hot blast has been lately considerably intensified by the use of Siemens's regene-

rative furnace. The reader wishing further information respecting these furnaces will find a description of them in the articles *Heat* and *Iron* in "Tomlinson's Cyclopædia of Useful Arts." The results obtained are an increased temperature, a saving in the amount of fuel used per ton of iron obtained, and a better quality of iron.

Cast-iron is divided by the iron-founder into three qualities:—No. 1, or dark grey cast-iron, is coarse-grained, soft, and not very tenacious. When remelted, it passes into No. 2, or grey cast-iron. This is the best quality for castings requiring strength. When repeatedly remelted, it becomes excessively hard and brittle and passes into No. 3, or white cast-iron, which is only used for the commonest castings, as sash weights, cannon balls, and similar articles.

White cast-iron if produced direct from the ore is an indication of derangement in the working of the furnace, and is unfit for the ordinary purposes of the founder, except to mix with other qualities.

Girders and similar solid articles are cast in sand moulds enclosed in iron frames or boxes, each mould requiring upper and lower boxes. A mould is formed by pressing sand firmly round a wooden pattern, which is afterwards removed, and the melted metal poured into the spaces thus left through apertures made for that purpose.

The moulds for ornamental work and for hollow castings are of a more complicated construction, which will be better understood from actual inspection at a foundry than from any written description. Almost all irons are improved by admixture with others, and therefore where superior castings are required they should

not be run direct from the smelting furnace, but the metal should be remelted in a cupola furnace, which gives the opportunity of suiting the quality of the iron to its intended use. Thus for delicate ornamental work a soft and very fluid iron will be required, whilst for girders and castings exposed to cross strain the metal will require to be harder and more tenacious. For bed-plates and castings which have merely to sustain a compressing force, the chief point to be attended to is the hardness of the metal.

Castings should be allowed to remain in sand until cool, as the quality of the metal is greatly injured by the rapid and irregular cooling which takes place from exposure to air if removed from the moulds in a red-hot state, which is sometimes done in small foundries to economise room.

Staffordshire, Shropshire, and Derbyshire afford the best iron for castings. The Scotch iron is much esteemed for hollow wares, and has a beautifully smooth surface, which may be noticed in the stoves and other articles cast by the Carron Company. The Welsh iron is principally used for conversion into bar-iron.

The conversion of forge pig into bar-iron is effected by a variety of processes, which have for their object the freeing of the metal from the carbon and other impurities combined with it, so as to produce as nearly as possible the pure metal.

Besides cast-iron columns, girders, and similar articles which are cast to order, the founder supplies a great variety of articles which are kept in store for immediate use, as cast-iron palings, balconies, rain water-pipes, and guttering, air-traps, coal-plates, stoves, stable-fittings, iron sashes, &c., &c.

Both wrought and cast-iron work are paid for by weight, except small articles kept in store for immediate use, which are valued per piece :—

One cubic foot of cast-iron	weighs about	450	lbs.
Ditto ditto of wrought	„	480	„
Ditto ditto of closely-hammered .	„	485	„

The coppersmith provides sheet copper for covering roofs, copper-gutters, and rain water-pipes; washing and brewing coppers; copper cramps and dowels for stone-mason's work, and all other copper work in a building; but the cost of the material in which he works prevents its general use, and the washing-copper is frequently the only part of a building which requires the aid of this artificer. Sheet copper is paid for by the superficial foot, copper in dowels, bolts, &c., at per pound.

Warming apparatus, steam and gas-fittings, and similar kinds of work are put up by the mechanical engineer, who also manufactures a great variety of articles which are purchased in parts, and put together and fixed by the plumber, as pumps, taps, water-closet apparatus.

SLATER.

The business of the slater chiefly consists in covering the roofs of houses with slates; but it has of late years been very much extended by the general introduction of sawn slates as a material for shelves, cisterns, baths, chimney-pieces, and even for ornamental purposes.

We propose here to describe only those operations of the slater which have reference to the covering of roofs. Besides the tools which are in common use among other artificers, the slater uses one peculiar to his trade

called the *zax,* which is a kind of hatchet with a sharp point at the back. It is used for trimming slates and making the holes by which they are nailed in their places.

Slates are laid either on boarding or on narrow battens from two to three inches wide, the latter being the more common method on account of its being less expensive than the other. The nails used should be either copper or zinc; iron nails, though sometimes used, being objectionable from their liability to rust. Every slate should be fastened with two nails, except in the most inferior work. The upper surface of a slate is called its *back,* the under surface the *bed,* the lower edge the *tail,* the upper edge the *head,* the part of each course of slate exposed to view is called the *margin* of the course, and the width of the margin is called the *gauge.*

The *bond* or *lap* is the distance which the lower edge of any course overlaps the slates of the second course below, measuring from the nail-hole.

In preparing slates for use, the sides and bottom-edges are trimmed, and the nail-holes punched as near the head as can be done without risk of breaking the slate, and at a uniform distance from the tail.

The lap having been decided on, the gauge will be equal to half the distance from the tail to the nail-hole, less the lap; thus a countess slate measuring nineteen inches from tail to nail, if laid with a three inch lap, would show a margin of eight inches. The battens are of course nailed on to the rafters at the gauge to which the slates will work. If the slates are of different lengths, they must be sorted into sizes and gauged accordingly, the smallest size being placed nearest the

ridge. The lap should not be less than two inches, and need not exceed three inches.

It is essential to the soundness, as well as the appearance of slater's work, that the slates should all be of the same width, and the edges perfectly true. The Welsh slates are considered the best, and are of a light sky-blue colour; the Westmoreland slates are of a dull greenish hue.

Slater's work is measured by the square of 100 superficial feet, allowance being made for the trouble of cutting the slates at the hips, eaves, round chimneys, &c.

Slabs for cisterns, baths, shelves, and other sawn work, are charged per foot, superficial, according to the thickness of the slab, and the labour bestowed on the work. Rubbed edges, grooves, &c., are charged per lineal foot.

A journeyman slater receives 9*d.* per hour, and his labourer about $6\frac{1}{2}d.$ per hour.

TABLE

Of the Sizes of Roofing Slates.

Description	Size. Length. ft.	in.	Size. Breadth ft.	in.	Average Lap in Inches.	No. of Squares 1200 will cover.	Weight per 1200 in Tons.	No. required to cover one Square.	No. of Nails required to one Square.
Doubles	1	0	0	6	$2\frac{1}{2}$	$2\frac{1}{2}$	$\frac{3}{4}$	480	480
Ladies	1	4	0	8	$2\frac{1}{2}$	$4\frac{1}{2}$	$1\frac{1}{4}$	266	280
Countesses	1	8	0	10	$2\frac{1}{2}$	$7\frac{1}{2}$	2	165	352
Duchesses	2	0	1	0	$2\frac{1}{2}$	$10\frac{3}{4}$	3	112	254
Imperials	2	6	2	0					
Rags and Queens	3	0	2	0	A Ton will cover $2\frac{1}{4}$ to $2\frac{1}{2}$ squares.				
Westmoreland of various sizes									

Inch slab per foot superficial weighs 15 lbs.

We have now endeavoured to explain the various trades employed, and the materials required for the carcass of a building, and will commence with the finishings.

Finishings.

The work of the plasterer consists in covering the brickwork and native timbers of walls, ceilings, and partitions with plaster, to prepare them for painting, papering, or distempering, and in forming cornices, and such decorative portions of the furnishings of buildings as may be required to be executed in plaster or cement.

The plasterer uses a variety of tools, of which the following are the principal ones :—

The *drag* is a three pronged rake, used to mix the hair with the mortar in preparing coarse stuff.

The *hawk* is a small square board for holding stuff on, with a short handle on the under side.

Trowels are of two kinds, the *laying and smoothing tool,* with which the first and the last are laid, and the *gauging trowel* used for gauging fine stuff for cornices, &c., &c. : these are made of various sizes, from three to seven inches long.

Of *floats,* which are used in floating ceilings and other work, there are three kinds, viz., the *Derby,* which is a rule of such a length as to require two men to use it ; the *hand-float,* which is used in furnishing stucco ; and the *quirk-float,* which is used in floating angles.

Moulds, for raising cornices, are made of sheet copper cut to the profile of the moulding, to be formed and fixed in a wooden frame.

Stopping and *picking out tools* are made of steel, seven or eight inches long, and of various sizes. They are used for modelling, and for finishing mitres, and returns to cornice.

Materials.

Coarse stuff, or lime and hair, as it is usually called, is similar to common mortar, with the addition of hair from the tanner's yard, which is thoroughly mixed with the mortar by means of the drag.

Fine stuff is made of pure lime, slaked with a small quantity of water; after which sufficient water is added to bring it to the consistence of cream. It is then allowed to settle, and the superfluous water being poured off, it is left in a bin or tub to remain in a semi-fluid state, until the evaporation of the water has brought it to a proper thickness for use. In using fine stuff for setting ceilings, a small portion of white hair is mixed with it.

Stucco is made with fine stuff and clean washed river sand. This is used for finishing work intended to be painted.

Gauged stuff is formed of fine stuff mixed with plaster of Paris, the proportion of plaster varying according to the rapidity with which the work is required to set.

Gauged stuff is used for running cornices and mouldings.

Enrichments, such as pateras, centre flowers for ceilings, &c., are first modelled in clay, and afterwards cast of plaster of Paris in wax or plaster moulds.

Papier maché ornaments also are much used, and have the advantage of being very light, and being easily and securely fixed with screws.

The variety of compositions and cements made use of by the plasterer is very great. *Roman cement, Portland cement,* and *lias cement,* are the principal ones used for coating buildings externally. Martin and Keene's cements are well adapted for all internal plastering where sharpness, hardness, and delicate finish are required.

Operations for Plastering.

When brickwork is plastered, the first coat is called *rendering.*

In plastering ceilings and partitions, the first operation is *lathing.* This is done with *single, one-and-a-half* or *double* laths, these names denoting their respective thicknesses. Laths are either of oak or fir; if of the former, wrought-iron nails are used, but cast-iron nails may be employed with the latter. The thickest laths are used for ceilings, as the strain on the laths is greater in a horizontal than in an upright position.

Pricking-up is the first coat of plastering of coarse stuff upon laths; when completed, it is well scratched over with the end of a lath, to form a key for the next coat.

Laid work consists of a simple coat of coarse stuff over a wall or ceiling.

Two-coat work is only roughed over with a broom, and afterwards set with fine stuff, or with gauged stuff in the better description of work.

The laying on of the second coat of plastering is called *floating,* from its being floated or brought to a plain surface with the float.

The operation of floating is performed by surrounding the surface to be floated with narrow strips of plastering called *screeds,* brought perfectly upright, or level, as

the case may be, with the level or plumb rule; thus, in preparing for floating a ceiling, nails are driven in at the angles, and along the sides, about ten feet apart, and carefully adjusted to a horizontal plane, by means of the level. Other nails are then adjusted opposite to the first, at a distance of seven or eight inches from them. The space between each pair of nails is filled up with coarse stuff, and floated perfectly true with a floating rule; this operation forms a screed, perfectly level throughout. Other screeds, are then formed, to divide the work into bays about eight feet wide, which are successively filled up flush, and floated level with the screeds.

The screeds for floating walls are formed in exactly the same manner, except that they are adjusted with the plumb rule instead of the level. After the work has been brought to an even surface by the floating rule, it is gone over with the hand float and a little soft stuff, to make good any deficiencies that may appear. The operation of forming screeds and floating work, which is not either vertical or horizontal, as a plaster floor laid with a fall, is analogous to that of taking the face of a stone out of winding, with chisel, drafts, and straight edges in stone-cutting, the principle being in each case to find three points in the same plane, from which to extend operations over the whole surface.

Setting.

When the floating is about half dry, the setting or finishing coat of fine stuff is laid on with the smoothing trowel, which is alternately wetted with a brush, and worked over with the smoothing tools, until a fine surface is obtained.

Stucco is laid on with the largest trowel and worked over with the hand-float, the work being alternately sprinkled with water and floated until it becomes hard and compact, after which it is finished by rubbing it over with a dry stock brush. The water has the effect of hardening the face of the stucco, so that after repeated sprinklings and trowelling, it becomes very hard, and smooth as glass.

The above remarks may be briefly summed up as follows. The commonest kind of work consists of only one coat, and is called *rendering*, on brickwork, and *laying*, if on laths. If a second coat be added, it becomes two-coat work, or *render set*, or *lath lay* and *set*. When the work is floated it becomes three-coat work, and is *render*, *float*, and *set* for brickwork, and *lath*, *lay*, *float*, and *set* for ceilings and partitions; ceilings being set with fine stuff and a little white hair, and walls intended for paper with fine stuff and sand; stucco is used where the work is to be painted.

Rough stucco is a mode of finishing staircases, passages, &c., in imitation of stone. It is mixed with a large proportion of sand, and roughened by the hand-float, to give it the appearance of stone.

Rough-cast is a mode of finishing outside work, by dashing over the second coat of plastering, whilst quite wet, a layer of rough cast, composed of well-washed gravel mixed up with pure lime and water till the whole is in a semi-fluid state.

Pugging is lining the spaces between floor joists with coarse stuff, to prevent the passage of sound, or between two stones, and is done on laths or rough boarding.

In the midland districts of England reeds were once used instead of laths, not only for ceilings and parti-

tions, but for floors, which were formed with a thick layer of coarse gauged stuff upon reeds. Floors of this kind were extensively used about Nottingham, and, from the security against fire afforded by the absence of wooden floors, Nottingham houses were considered fire-proof.

Plasterer's work is measured by the superficial yard, cornices by the superficial foot, enrichments to cornices by the lineal foot, and centre flowers and other decorations at per piece.

Memoranda.

The wages of a journeyman plasterer are $9\frac{1}{2}d.$ per hour; those engaged on modelling and ornamental work will earn much more. A labourer receives $6\frac{1}{2}d.$ per hour.

Lathing.—One bundle of laths and 384 nails will cover 5 yards superficial measure.

Rendering.—$187\frac{1}{2}$ yards require $1\frac{1}{2}$ hundred of lime, 2 double loads of sand, and 5 bushels of hair.

Floating requires more labour, but only half as much material as rendering.

Setting.—375 superficial yards require $1\frac{1}{2}$ hundred of lime and 5 bushels of hair.

Render Set.—100 yards superficial require $1\frac{1}{2}$ cwt. of lime, 1 double load of sand, and 4 bushels of hair, and the work of plasterer, labourer, and boy, for 3 days each.

Lath, Lay and Set.—135 yards superficial of lath, lay and set require 1 load of laths, 7,000 nails, 56 bushels of lime, 75 bushels of sand, and 5 bushels of hair. Plasterer, labourer, and boy, 6 days each.

Twenty per cent. profit is allowed upon all materials.

JOINER.

The work of the joiner consists in framing and joining together the wooden finishings and decorations of buildings, both internal and external; such as floors, staircases, framed partitions, skirtings, solid door and window frames, hollow or cased window frames, sashes and shutters, doors, columns and entablatures, chimney-pieces, &c.

The *joiner's* work requires much greater accuracy and finish than that of the carpenter, and differs materially from it in being brought to a smooth surface with the plane wherever exposed to view, whilst with the carpenter's work the timber is left rough as it comes from the saw.

The *joiner* uses a great variety of tools: the principal cutting tools are saws, planes, and chisels.

Of saws there are a great variety, distinguished from each by their shape and by the size of their teeth. The *ripper* has 8 teeth in 3 inches; the *half ripper* 3 teeth to the inch; the *hand-saw*, 15 teeth in 4 inches; the *panel-saw*, 6 teeth to the inch. The *tenon-saw*, used for cutting tenons, has about 8 teeth to the inch, and is strengthened at the back by a thick piece of iron to keep the blade from buckling. The *sash-saw* is similar to the tenon-saw, but is backed with brass instead of iron, and has 13 teeth to the inch; the *dovetail-saw* is still smaller, and has 15 teeth to the inch. Besides the above named, other saws are used for particular purposes—as the *compass-saw* for cutting circular work, and the *keyhole-saw* for cutting small holes. The *carcase-saw* is a large kind of *dovetail-saw*, having about 11 teeth to an inch.

Planes are also of many kinds: those called *bench planes*—as the *jack-plane*, the *trying-plane*, the *long plane*, the *jointer*, and the *smoothing-plane*—are used for bringing the stuff to a plane surface. The jack-plane is about 18 inches long, and is used for the roughest work. The trying-plane is about 22 inches long, and used after the jack-plane for *trying-up*—that is, taking off shavings the whole length of the stuff. Whilst using the *jack-plane*, the workman stops at every arm's length. The *long-plane* is about 2 feet 3 inches long, and used when a piece of stuff is to be tried-up very straight. The *jointer* is about 2 feet 6 inches long, and is used for trying-up or *shooting* the *joints*, in the same way as the *trying-plane* is used for trying-up the face of the stuff. The *smoothing-plane* is small, being only about 7½ inches long, and is used on almost all occasions for cleaning or smoothing-off finished work. *Rebate-planes* are used for sinking rebates, and vary in their size and shape according to their respective uses. *Rebate-planes* differ from *bench-planes* in having no handle rising out of the stock, and in discharging their shavings at the side. Amongst the rebate-planes may be mentioned the *moving fillister* and the *sash fillister*, the uses of which will be better understood from inspection than description. *Moulding-planes* are used for *sticking mouldings*, as the operation of forming mouldings with the plane is called. When mouldings are worked with chisels instead of with planes, they are said to be worked by *hand*. Of the class of moulding-planes, although kept separate in the tool chest, are hollows and rounds, beads, &c., of various sizes.

There are other kinds of planes besides the above-named, as the *plough,* for sinking a groove to receive a projecting tongue; the *bead,* for sticking beads; the *snipe's-bill,* for forming and cleaning out quirks; the *compass-plane* and the *forkstaff-plane,* for forming concave and convex cylindrical surfaces. The shape and use of these and many other tools used by the joiner will be better understood by inspection than description.

Chisels are also varied in their form and use: some are used merely with the pressure of the hand, as the *paring chisel;* others by the aid of a mallet, as the *socket chisel* (so named from the iron at the top forming a socket to receive an iron handle), for cutting away superfluous stuff; and the *mortice chisel,* for cutting mortices: the gouges are curved chisels.

The joiners use a great variety of boring tools, as the *brad-awl, gimlet,* and *stock and bit.* The last form but one tool, the *stock* being the *handle,* to the hollow of which may be fitted a variety of steel bits of different bores and shapes, for boring and widening out holes in wood and metal, as *countersinks, rimers,* and *taper shell-bits.*

The *screw-driver, pincers, hammer, mallet, hatchet,* and *adze* are too well known to require description.

The *gauge* is used for drawing lines on a piece of stuff parallel to its edges.

The *bench* is one of the most important of the joiner's implements. It is furnished with a vertical *sideboard,* perforated with diagonal ranges of holes, which receive the *bench-pin,* on which to rest the lower end of a piece of stuff to be planed, whilst the upper end is firmly clamped by the *bench-screw.*

The *mitre-box* is used for cutting a piece of stuff to a mitre, or an angle of forty-five degrees, with one of its sides.

The joiner uses for setting out and fixing his work the *straight edge*, the *square*, the *level* or square with a shifting blade, the *mitre square*, the *level*, and *plumb rule*.

In addition to the tools and implements above enumerated, the execution of particular kinds of work requires other articles, as *cylinders*, *templets*, *cramps*, &c., the description of which would unnecessarily extend the limits of our present object.

The principal operations of the joiner are sawing, planing, dovetailing, morticing, and scribing.

The manner of forming a dovetail is by inserting a wedge-shaped projecting piece, called the pin, into a corresponding hole made to receive it, which is called a *socket*.

Morticing is executed by forming a hole in a piece of timber to receive the end of another piece, called the *tenon*. The tenon is sometimes *pinned* in its place with oak pins driven through the cheeks of the mortice; but in forming doors, shutters, &c., the tenon is secured with tapering wedges driven into the mortice, which is cut slightly wider at the top than the bottom, the adhesion of the glue with which the tenon and wedges are first rubbed over making it impossible for the tenon afterwards to draw out of its place.

Joints in the length of the stuff may be either *square*, *rebated*, or *grooved and tongued*, which is executed by a groove made with a plough and iron on each edge of the two pieces of stuff, and then a slip of

wood, which is called the *tongue*, being inserted before the joint is glued up.

Scribing is the drawing on a piece of stuff the exact profile of some irregular surface to which it is to be made to fit; this is done with a pair of compasses, one leg of which is made to traverse the irregular surface, the other to *describe* a line *parallel* thereto along the edge of the stuff to be cut.

In the execution of *circular work*, or as it is frequently termed *sweep work*, there are four different methods by which the stuff can be brought to the required curve:—

Firstly. It may be steamed and bent into shape.

Secondly. It may be glued up in thicknesses which must, when thoroughly dry, be planed true, and, if not to be painted, covered with a thin veneer, bent round it.

Thirdly. It may be formed in thin thicknesses bent round and glued up in a mould. This may be considered the most perfect of all the methods in use.

Lastly. It may be formed by sawing a number of notches on one side, by which means it becomes easily bent in that direction, but the curve produced by this means is very irregular, and it is an inferior mode of execution compared to the others.

When a number of boards are secured together by cross pieces or *ledges* nailed or screwed at the back, the work is said to be *ledged;* ledged work is for common purposes, as cellar-doors, outside shutters, &c.

Framed work consists of *styles* and *rails* morticed and tenoned together, and filled in with panels, the edges of which fit in grooves cut for the purpose in the *styles* and *rails*.

Work is said to be *clamped* when it is prevented from

warping or splitting by a rail at each end. If the ends of the rail are cut off it is said to be *mitre-clamped.*

There are several ways of laying floors practised by joiners. In laying what is called a *straight-joint floor,* from the joints between the boards running in an unbroken line from wall to wall, each board is laid down and nailed in succession, being first forced firmly against the one last laid with a flooring cramp.

Folding floors are laid by nailing down first every fifth board, rather closer together than the united widths of four boards, and forcing the intermediate ones into the space left for them by jumping on them. This method of laying floors is resorted to when the stuff is imperfectly seasoned and is expected to shrink, but it should never be executed in good work. The narrower the stuff with which a floor is laid the less will the joints open, on account of the shrinkage being distributed over a greater number of joints. The floor boards may be nailed at their edges, and grooved and tongued or dowelled, if a perfect floor is wanted. Dowelling is superior to grooving and tonguing, because the cutting away the stuff to receive the tongue greatly weakens the edges of the joint, which are apt to curl.

Glue is an article of great importance to the joiner, the strength of his work depending much upon its adhesive properties. The best glue is made from the skins of animals, that from the sinewy or horny parts being of inferior quality. The strength of the glue increases with the age of the animals from which the skins are taken.

Joiner's work is measured by the superficial foot, according to its description. Floors by the square of 100 feet superficial. Hand-rails, small mouldings,

water-trunks, and similar articles, per lineal foot. Cantilevers, trusses, cut-brackets, scrolls to handrails, &c., are valued per piece.

The wages of a joiner are $9\frac{1}{2}d.$ per hour.

The following memoranda relative to joiner's work may be found useful:—

One Square of Rough Flooring will take—

24	10-feet boards	at	. .	5-inch gauge.
20	,, ,,	at	. .	6-inch ditto.
17	,, ,,	at	. .	7-inch ditto—10 in. wanted.
15	,, ,,	at	. .	8-inch ditto.
13	,, ,,	at	. .	9-inch ditto—2 ft. 6 in. wanted.
12	,, ,,	at	. .	10-inch ditto.
20	12-feet boards	at	. .	5-inch gauge.
16	,, ,,	at	. .	6-inch ditto—8 ft. wanted.
14	,, ,,	at	. .	7-inch ditto—2 ft. wanted.
12	,, ,,	at	. .	8-inch ditto—4 ft. wanted.
11	,, ,,	at	. .	9-inch ditto—1 ft. wanted.
10	,, ,,	at	. .	10-inch ditto.

N.B.—One square of flooring will take 200 nails. To make them tough they should be heated in a fire-shovel or the like, with a bit of tallow or grease in them.

120 twelve-feet deals make one hundred; and the readiest way of calculating the price of a single one is to consider every pound per hundred as two-pence per deal: thus if deals are £40 per hundred, they are 40 times two-pence each, or 80 pence, which is 6*s.* 8*d.* for each deal; or if £36 10*s.* per hundred, they would be $36\frac{1}{2}$ times two-pence each, double of which, for pence, would be 73, or 6*s.* 1*d.* each deal, and in the same way for any other given price.

120 12-feet 3-inch deals equal 4 loads of timber.
400 superficial feet $1\frac{1}{2}$-inch deals weigh one load.

Planks are 11 inches wide.
Deals ,, 9 ,,
Battens ,, 7 ,,

A reduced deal is $1\frac{1}{2}$ in. thick, 11 in. wide, and 12 feet long.

A square of flooring laid rough requires 12 12 ft. floor-boards 9 in. wide, if edges shot, $12\frac{1}{2}$. If wrought and laid folding, 13. Laid straight joint, $13\frac{1}{2}$. Wrought and laid straight joint, and ploughed and tongued, 14. If laid with 12 feet battens, wrought and laid folding, 17, and with straight joint, 18.

Sawing.

The *sawer* is to the carpenter and joiner what the stone-cutter is to the mason.

The pit saw is a large two-handed saw fixed in a frame, and moved up and down in a vertical direction by two men called the top-man and the pit-man, the first of whom stands on the timber that is to be cut, the other at the bottom of the saw-pit. The timber is *lined out* with a chalk line on its upper surface, and the accuracy of the work depends mainly on the top-man keeping the saw to the line, whence the proverbial expression *top-sawyer,* meaning one who directs any undertaking.

In sawing deals and battens into thicknesses for the joiner's use, the parallelism of the cut is of the utmost importance, as the operation of *taking out of winding* a piece of uneven stuff causes a considerable waste of material, and much loss of time.

Circular-saws, moved by steam-power, are now much used in large establishments, timber-yards, &c., and effect a considerable saving of labour over the use of the pit-saw, where the timbers to be cut are not too heavy to be easily handled.

The saw is mounted in the middle of a stout bench

furnished with guides, by means of which the stuff to be cut is kept in the required direction, whilst it is pushed against the saw, which is the whole manual labour required in the operation.

IRONMONGERY

Is charged for, generally, with the work to which it is attached; the joiner being allowed 20 per cent. profit upon the prime cost.

The principal articles of ironmongery used in a building consist of *nails, screws, sash-pulleys, bolts, hinges, locks, latches,* and *sash* and *shutter-furniture,* besides a great variety of miscellaneous articles which we have not space to enumerate.

Of the different kinds of hinges may be mentioned *hook-and-eye hinges* for gates, coach-house doors, &c.; *butts* and *back-flaps* for doors and shutters; *cross garnets,* which are used for hanging ledged doors and other inferior work; H *and* H*-hinges,* whose names are derived from their shape; and *parliament hinges.*

Besides these are used *rising-butts* for hanging doors to rise over a carpet or other impediment, *projecting-butts,* used when some projection has to be cleared, and *spring-hinges* and swing centres for self-shutting doors.

The variety of locks now manufactured is almost infinite. We may mention the *stock-lock,* cased in wood for common work, and *rim-locks,* which have a metal case or rim, and are attached to one side of a door; they should not be used when a door has sufficient thickness to allow of a mortice-lock, as they often catch the dresses of persons passing through the door-

way. *Mortice-locks,* as the name implies, are those which are morticed into the thickness of the door.

The handles and escutcheons are called the *furniture* of a lock, and are made of a great variety of materials, as brass, bronze, ebony, ivory, and glass, &c.

Of latches, there are the common *thumb-latch,* the *bow-latch,* with brass knobs, the brass *pulpit-latch,* and the *mortice-latch.*

There are also a great variety of other articles, both useful and ornamental, kept in stock and supplied by the furnishing ironmonger.

GLAZIER.

The business of the glazier consists in cutting glass, and fixing it into *lead-work, wood-work,* or wood sashes. The former is the oldest method of glazing, and is still used, not only for cottage windows and inferior work, but for church windows and glazing with stained glass, which is cut into pieces of the required size, and set in a leaden framework; this kind of glazing is called *fretwork.* Glazing in sashes is of comparatively modern introduction. The sash bars are formed with a rebate on the outside for the reception of the glass, which is *cut into* the rebate, and firmly *beaded* and *back-puttied* to keep it in its place. Large squares are also *sprigged* or secured with small brads driven into the sash bars.

Glazing in lead-work is fixed in leaden rods called *cames,* prepared for the use of the glazier by being passed through a glazier's vice, in which they receive the grooves for the insertion of the glass. The sides or cheeks of the grooves are sufficiently soft to allow of their being turned down to admit the glass, and

again raised up and firmly pressed against it after its insertion. For common lead-work, the bars are soldered together so as to form squares or diamonds. In fret-work, the bars, instead of being used straight, are bent round to the shapes of the different pieces of glass forming the device. Lead-work is strengthened by being attached to *saddle-bars* of iron, by leaden bars soldered to the lead-work and twisted round the iron.

Putty is made of pounded whiting beaten up with linseed oil into a tough tenacious cement.

The principal tool of the glazier is the *diamond*, which is used for cutting glass. This tool consists of an unpolished diamond fixed in lead, and fastened to a handle of hard wood.

The glazier uses a *hacking-knife* for cutting out old putty from broken squares, and the *stopping-knife* for laying and smoothing the putty when *stopping-in* glass into sashes. For setting glass into lead-work, the *setting-knife* is used.

Besides the above, the glazier requires a square and straight edge, and a pair of compasses, for dividing the tables of glass to the required sizes. Also, a hammer for springing large squares, and brushes for cleaning off the work.

The *glazier's vice* has already been mentioned. The *latter-kin* is a pointed piece of hard wood, with which grooves of the *cames* are cleared out and widened for receiving the glass.

Cleaning windows is an important branch of the glazier's business in most large towns; the glazier taking upon himself the cost of all glass broken in the operation. Glazier's work is valued by the superficial

foot, the price increasing with the size of the square. Irregular panes are valued according to the extreme dimensions each way.

Crown glass is *blown* in circular *tables*, from 3 feet 6 inches to 5 feet diameter, and is sold in *crates*, the number of tables in a crate varying according to the quality of the glass.

A crate contains		12	tables	of best quality.
Ditto	ditto	15	„	second ditto.
Ditto	ditto	18	„	third ditto.

Plate glass is cast in large plates on horizontal tables, and afterwards polished.

The manufacture of sheet or spread glass, which was formerly considered a very inferior article, has of late years been much improved. Much is now sold, after being polished, under the name of patent plate.

PAINTER, PAPER-HANGER, AND DECORATOR.

The business of the house-painter consists in covering with a preparation of white lead and oil such portions of the joiner's, smith's, and plasterer's work as require to be protected from the action of the atmosphere. Decorative painting is a higher branch, requiring a knowledge of the harmony of colours, and more or less artistic skill, according to the nature of the work to be executed.

The introduction of fresco painting into this country, as a mode of internal decoration, has led to the employment of some of the first artists of the day in the embellishment of the mansions of the nobility, and the example thus set will no doubt be extensively followed.

The principal materials used by the painter are—*white lead*, which forms the basis of all the colours used

in house-painting; *linseed oil* and *spirits of turpentine*, used for mixing and diluting the colours; and *dryers*, as *litharge*, *sugar of lead*, and white vitriol, which are mixed with the colours to facilitate their drying. *Putty*, made of whiting and linseed oil, is used for *stopping* or filling up nail holes and other vacuities, in order to bring the work to a smooth face.

The painter's tools are few and simple: they consist of the *grinding-stone* and *muller*, for grinding colours; *earthen pots*, to hold colours; *cans* for oil and turps; *pallet knife*, and brushes of various sizes and descriptions. In painting wood, the first operation consists in killing the *knots*, from which the turpentine would otherwise exude and spoil the work. To effect this, the knots are covered with fresh slaked lime, which dries up and burns out the turpentine; when this has been on twenty-four hours, it is scraped off, and the knots painted over with a mixture of red and white lead mixed with glue size. After this, they are gone over a second time with red and white lead mixed with linseed oil; when dry, they must be rubbed perfectly smooth with pumice stone, and the work is then ready to receive the priming coat.

This is composed of red and white lead, well diluted with linseed oil.

The nail holes and other imperfections are then stopped with putty, and the succeeding coats are then laid on, the work being rubbed down between each coat with pumice stone, to bring it to an even surface. The first after the priming is mixed with linseed oil and a little turpentine; the second coat with equal quantities of linseed oil and turpentine.

In laying on the second coat where the work is not

to be finished white, an approach must be made to the required colour. The third coat is usually the last, and is made with a base of white lead, mixed with the requisite colours, and diluted with one-third of linseed oil to two-thirds of turpentine.

Painting on stucco, and all other work in which the surface is required to be without gloss, has an additional coat mixed with turpentine only, which from its drying of one uniform *flat* tint is called a flatting coat. If the knots show through a second coat they must be carefully covered with silver leaf. Work finished as above described would be technically specified as knotted, primed, painted three oils, and flatted. Flatting is almost indispensable in all delicate interior work, but it is not suited to outside work, as it will not bear exposure to the weather. Painting on stucco is primed with boiled linseed oil, and should then receive at least three coats of white lead and oil, and be finished with a flat tint.

The great secret of success in painting stucco is, that the surface should be perfectly dry, and as this can hardly be the case in less than two years after the erection of a building, it will always be desirable to finish new work in distemper, which can be washed off whenever the walls are sufficiently dry to receive the permanent decorations.

Graining is the imitation of the grain of various kinds of wood, by means of *graining tools,* and, when well executed and properly varnished, has a handsome appearance, and lasts many years. The term graining is also applied to the imitation of marble.

Clear coling is a substitution of size for oil, in the preparation of the priming coat. It is much resorted

to by painters on account of the ease with which a good face can be put on the work with fewer coats than when oil is used, but it will not stand damp, which causes it to scale off, and it should never be used except in painting old work, which is greasy or smoky, and cannot be made to look well by any other means.

Distempering is a kind of painting in which whiting is used as the basis of the colours, the liquid medium being size; it is much used for ceilings and walls, and will require two, and sometimes three coats, to give it a uniform appearance.

Painter's work is valued per superficial yard, according to the number of coats, and the description of work, as *common* colours, *fancy* colours, *party* colours, &c.

Where work is cut on both edges, it is taken by the lineal foot. In measuring railings, the two sides are measured as flat work. Sash frames are valued per piece, and sashes per dozen squares.

The manufacture of *scagliola,* or imitation marble, is a branch of the decorator's business which is carried to very great perfection. Scagliola is made of plaster of Paris and different earthy colours, which are mixed in a trough in a moist state, and blended together until the required effect is produced, when the composition is taken from the trough, laid on the plaster ground, and well worked together with a wooden beater and a small gauging trowel. When quite hard, it is smoothed, scraped, and polished, until it assumes the appearance of marble.

Scagliola is valued at per foot *superficial,* according to the description of marble imitated and the execution of the work.

Gilding is executed with leaf-gold, which is furnished by the gold-beater in books of twenty-five leaves, each leaf measuring $3\frac{1}{2}$ by 3 inches.

The parts to be gilded are first prepared with a coat of gold-size, which is made of Oxford ochre and fat oil.

The operations of the paper-hanger are so simple as to require little description. There are as great a variety of patterns as there are of prices, and the expense of hanging them is generally regulated by the value of the paper, as the most expensive papers require more time and attention than the plainer sorts.

A piece of paper is twelve yards long, and is twenty inches wide when hung, and covers sixty feet superficial, hence the number of superficial feet that have to be covered divided by sixty, will give the number of pieces required for any description of work.

CHAPTER V.

ARCHITECTURAL DRAWING.*

HAVING thus far described most of the principal tools and materials used in the several trades engaged in the erection of dwelling-houses, it is necessary that the young artisan should now give attention to lineal drawing. We are now desirous of conveying our opinion (founded upon many years' experience, both theoretically and practically) of its utility and importance; and in doing so, we may not probably assume too much, by stating that not any mechanic in the building department, or in fact in any other, can ever be efficient in his

* See Heather's "Descriptive Geometry," and his "Mathematical Instruments," both in this series.

business unless he comprehends the application of scales and the elementary principles of geometrical drawing.

Until late years there was not that attention paid to this art which its general application and usefulness demanded, it being considered more an acquisition for the mathematician, artist, or amateur, than the mechanician. But the progress that has been made within the last half century in every branch of mechanical art has rendered necessary a practical and theoretical knowledge of at least the rudiments of mechanical drawing; and the want has been met by the Schools of Art, which afford, at a comparatively low cost, instruction in this important auxiliary to the various arts of design and ornamentation.

That geometrical drawing to the young mechanic may at first be considered a dry and useless study is admitted, but he must recollect that no one ever rose to eminence in any of the arts or sciences without perseverance and intense application, and although the study here particularly alluded to may be considered dry and uninteresting at first, it will be rewarded by the pleasure and confidence it gives to its possessor hereafter.

It is a well-known fact that without a knowledge of scales and their application, and an elementary acquaintance with the principles of geometry, no one, however well-informed on other subjects, can convey the emanation of his mind for any practical mechanical purpose.* He certainly may be enabled in a cursory manner to sketch out his ideas, but they cannot with any certainty be carried into practical execution, unless they are geometrically delineated to a scale. Having

* See Warren's "General Problems of Shades and Shadows," one of the best books on the subject.

thus expressed our views upon the usefulness and application of drawing, we will now endeavour to explain the paper in general use for drawing, and the particular use of such scale and mathematical instruments as are essential for him to possess.

A TABLE OF THE DIMENSIONS OF DRAWING-PAPER.*

	Inches.		Inches.
Demy	20	by	15½
Medium	22¾	„	17½
Royal	24	„	19½
Super Royal	27¼	„	19¼
Imperial	30	„	22
Elephant	28	„	23
Columbier	35	„	23½
Atlas	34	„	26
Double Elephant	40	„	27
Antiquarian	53	„	31
Emperor	68	„	48

HINTS ON THE MANAGEMENT OF DRAWING PAPER.

The first thing to be done preparatory to the commencement of a drawing is the preparation of the paper, that is, the stretching it evenly upon a drawing-board. The edges of the paper should first be cut straight, and as near as possible at right angles with each other. Also the sheet should be so much larger than the intended drawing and its margin, as to admit of being afterwards cut from the board, leaving the border by which it is attached thereto, by glue or paste, as we shall next explain. The paper must be thoroughly and equally damped with a sponge and clean water on the opposite side from that on which the drawing is to be made. When the paper absorbs the water, which may be seen by the wetted side becoming dried, as its surface is viewed slant-ways against the light, it is to be laid

* It is assumed that the student is fully acquainted with the use of the drawing-boards, T-squares, set squares, and parallel rulers.

on the drawing-board with the wetted side downwards, and placed so that the edges may be nearly parallel with those of the board, otherwise in using a T-square an inconvenience may be experienced. This done, lay a straight-edge on the paper with the margin parallel to and about half an inch from one of the edges of the paper. The straight-edge or ruler must now be held firm while the said projecting half-inch of paper is turned up against it; then a piece of glue, previously softened by a few seconds' exposure to the steam from a basin of hot water, must be passed once or twice along the turned up edge of the paper, after which, by sliding the ruler over the glued border, it will again be laid flat, and the ruler or straight-edge being pressed down upon it, that edge of the paper will adhere to the board. If sufficient glue has been applied the ruler may be removed directly, and the edge finally rubbed down by an ivory book-knife, or any clean polished substance at hand, which will then firmly cement the paper to the board. This done, another but adjoining edge of the paper must be acted upon in a like manner, and then the remaining edges in succession; we say the adjoining edges, because we have occasionally observed that when the opposite and parallel edges have been laid first, without continuing the process progressively round the board, a greater degree of care is required to prevent undulations in the paper as it dries.

Sometimes strong paste is used instead of glue; but as this takes a longer time to set, it is usual to wet the paper also on the upper surface to within an inch of the paste mark, care being taken not to rule or injure the surface in the process; the wetting of the paper in either case is done for the purpose of expanding it, and

the edges being fixed to the board in its enlarged state acts as stretcher upon the paper while it contracts in drying, which it should be allowed to do gradually. All creases or undulations by this means disappear from the surface of the paper, and it is a smooth plane to receive the drawing.

In mounting paper upon canvas, the latter should be well stretched upon a smooth flat surface, being damped for that purpose, and its edges glued down as was recommended in stretching drawing paper; then with a brush spread strong paste upon the canvas, beating it in until the grain of the canvas be all filled up; for this, when dry, will prevent the canvas from shrinking when subsequently removed. Then, having cut the edges of the paper straight, paste one side of every sheet and lay them upon the canvas, sheet by sheet, overlapping each other a small quantity. If the drawing is strong it is best to let every sheet lie five or six minutes after the paste is put on it, for as the paste soaks in, the paper will stretch and may be better spread smooth upon the canvas, whereas, if it be laid on before the paste has moistened the paper, it will stretch afterwards and raise blisters when laid upon the canvas. The paper should not be cut off from its extended position till thoroughly dry, which should not be hastened, but left in a dry room to do so gradually if time permit, if not, it may be exposed to the rays of the sun, unless in the winter season, when the assistance of a fire is necessary, provided it is not placed too near a scorching heat. In joining two or more sheets of paper together by overlapping, it is necessary, in order to make a neat joint, to feather-edge each sheet, this is done by carefully cutting with a knife half-way through

the paper near the edge and on the sides which are to overlap each other, then strip off a feather edge or slip from each, which, if done dexterously, will form a very neat and efficient joint when put together. The following method of mounting and varnishing drawings or prints may be considered useful. Stretch a piece of linen on a frame, to which give a coat of isinglass or common size, paste the back of the drawing or print, which leave to soak and then lay it on the linen. When dry give it at least four coats of well-made isinglass size, allowing it to dry between each coat. Take Canada balsam diluted with the best oil of turpentine, and with a clean brush give it a full flowing coat.

Pencils.

In selecting black pencils for use, it may be remarked, that they ought not to be very soft nor so hard that their traces cannot be easily erased by the India rubber. Great care should be taken in the pencilling, that an accurate outline be drawn, the pencil marks should be distinct, yet not heavy, and the use of the rubber should be avoided as much as possible, for its frequent application ruffles the surface of the paper and will destroy the good effect of shading or colouring, if any is afterwards to be applied.

DRAWING INSTRUMENTS.

The Compasses.

The compasses or dividers are instruments so well known, that it would be superfluous to enter into a lengthy description of them, or of the various uses to which they may be applied. The best are constructed

with joints of two different metals, as steel and brass, whereby the wear is more equal, and the motion of the legs uniform and steady, and not subject to sudden jerks in opening or shutting; this motion will occasionally require some adjustment to render it uniformly smooth, and to move stiffer or easier at pleasure; but so that they may keep steadily any position that may be given to them, the adjustment is performed by the application of a turn-screw to this axis of the joint. In the common compasses a simple screw forms the axis upon which the legs move, and may be turned with a screw driver of the ordinary construction; but in the best made instruments a steel pin passes through the joints, having at one end a head of brass riveted fast upon it, and on the other end a similar plate is screwed, which is therefore a nut, on a diameter of which is drilled two small holes for the application of a lever of a particular description.

The points of a well-made instrument should be of steel, so tempered as neither to be easily bent or blunted; not too fine and tapering, and yet meeting closely when the compasses are shut. As some of the numerous uses to which this instrument may be applied, the following may be mentioned:—To take any extent or length between the points of the compasses, and to set it off or to apply it successively upon any line. To take any proposed line between the points, and by applying it to the proper scale, to find its length. To set off equal distances upon a given line, to describe circles, intersecting arcs, &c. To make an angle equal to any given angle; to lay off an angle of a given quantity upon an arc of circle from the line of cords, &c.; to construct any proposal in plotting, or drawing plans, &c., &c.

The Hair Compasses.

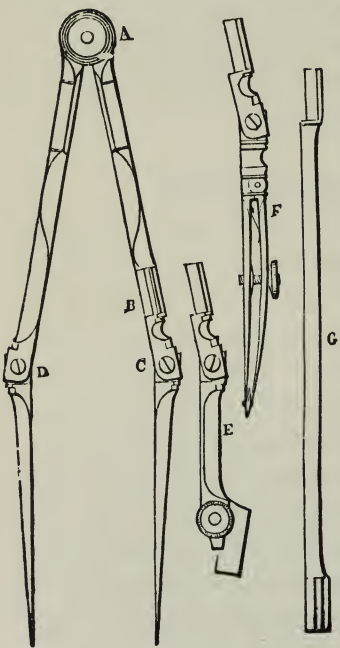
This instrument is represented in the adjoining engraving, and is constructed in the same manner as those above described. The only difference consists in a contrivance *b*, whereby the lower point, or half one shank, can be moved a very small quantity, either towards or from the other point, which is useful when a distance is required to be taken with the utmost possible exactness. This contrivance consists of a fine spring and screw, by which, when the compasses are opened nearly to the required extent by the help of the screw *b*, the points may be set to the greatest precision, which cannot be done so well by the motion of the joints *alone*.

Compasses with movable points.

In the smaller and more portable cases of drawing instruments, it is customary to insert a larger sized pair of compasses, of which the point of half of one of the legs is never movable, to admit of adapting singly a pen or pencil, or dotting points. The pen point is used for drawing circles or arcs with ink, and is constructed like the drawing-pen, which will be hereafter described; the pencil point is alike adapted to hold a piece of black lead pencil or crayon for describing circles or arcs that are not to be permanent, and the dotting point consists of two blades similar to those of the drawing pen, but rounded at the points, between which revolves a small wheel with numerous points round its circumference resembling the rowel of a spur. The space between the blades being supplied with Indian ink, and the

wheels rolled upon paper, as the compasses describe a circle or arc, each point as the wheel revolves will pass through the ink and transfer it to the paper beneath, making equi-distant dots in the circle which the compasses describe.

The movable points have a joint in them just under that part which locks into the shank of the compasses, by which the part below the joint may be set perpendicular to the plane on which the lines are described when the compasses are open. An additional piece, called a lengthening bar, is frequently applied to these compasses, which by lengthening the movable leg enables them to strike larger circles, or measure greater extents than they otherwise would perform. When this is applied, the movable part has a joint similar to those on the pen and pencil points, and for a similar purpose the annexed diagram represents this instrument and its appendages.

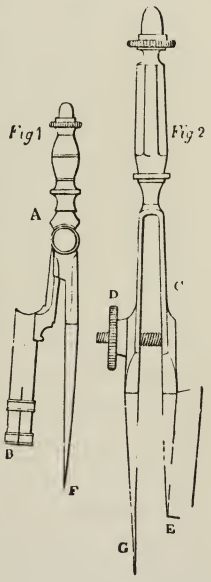


A the compasses with a movable point at B; C and D, the joints to set each point perpendicular to the paper; E the pencil point; F the pen point (this is represented with a dotting wheel, the pen point and the dotting point are similar in shape to each other); G the lengthening bar.

Bow Compasses.

These are a small pair having a point either for ink or pencil. They are used to describe small arcs or circles, which they do more conveniently than large compasses, not only on account of the size, but also from the shape of their head, which rolls easily between the fingers and can be turned round as delicately as they require to be moved for drawing very minute circles.

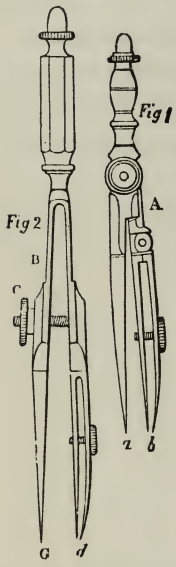
The adjoining figures represent the pencil bow as suited for describing arcs of different radii. Fig. 1 is a construction adapted for describing arcs of a radius intermediate between those described by the above-named compasses, and those capable of being produced by the bows represented by Fig. 2.



In Fig. 1 the pencil point B, and the centre point F, can be opened a considerable width by the joint A, whilst in the other construction, Fig. 2, the corresponding points E and G are limited in their opening, the two blades carrying the points, being formed out of one solid piece of steel, and tempered so as to form a spring at the upper part corresponding with the joint A in Fig. 1. The spring of the two blades is then kept in obedience by an adjusting screw D, by which the two points may be set to any required degree of minuteness, and very small circles may be described with a precision

that could not be expected or scarcely attempted by the construction of Fig. 1.

The pen bows are represented in the annexed engraving; their construction is similar to the pencil bows last described. In the pen point of Fig. 1, there is a second joint just below letter A, by which, when the instrument is open for use, the pen may be set perpendicular, or nearly so, to the paper, which is essential in the use of the drawing pen. This is a corresponding contrivance with that noticed in describing the compasses with movable points. In Fig. 2, B shows the spring blades carrying the points G and *d*, and C, the adjusting screw, to set these points to the required radius.

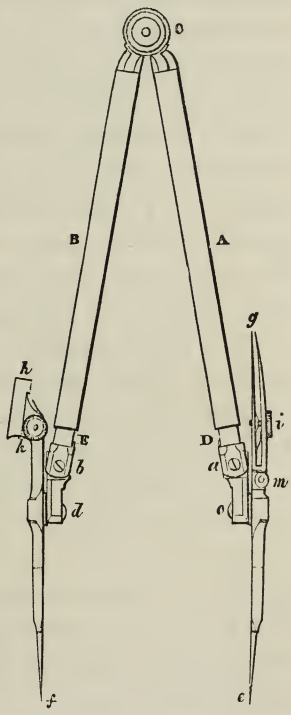


Tubular Compasses.

The engraving on page 75 represents this instrument. It may be used as an ordinary pair of compasses, either with two fine points, a pen point, or a pencil point, and is capable of describing circles to any extent of radius from an eighth of an inch to fourteen inches and a-half, and with the advantage of reversing points which may be changed from pen to pencil, &c., without deranging the setting of the instrument when opened to any definite extent.

A and B are the two principal legs of the instrument, consisting of tubes movable about a very nicely constructed joint at C. Within these are two sliding tubes E and D, which draw out their whole length, and are accurately fitted to the principal tubes A and B, so that

they may be drawn out to their required extent with a smooth and steady motion, not subject to sudden stoppages, or to move with equally sudden jerks, a proof of bad workmanship, but uniformly, and not too easy.* To assist in this, their inner extremities are made to act as springs within tubes, wherein they slide, thus increasing their friction.



The outward extremity of each of the sliding tubes E and D terminates in a square headed joint, *a* and *b*; upon these move the pieces *c* and *d*, which carry the point limbs of the compasses. The joints *a* and *b* in this instrument correspond with the joints C and D of the compasses with movable points as before described, and are used for a similar purpose, namely, to set the point limbs perpendicular to the paper, and consequently parallel to each other, at whatever opening the legs of the compasses may be extended to.

In our engraving, the pivots of the two point limbs *f*, *h* and *e*, *g* to the two carrying pieces, which are jointed to the tubes at *a* and *b*, also give the means of inverting the position of the points; that is to say, the

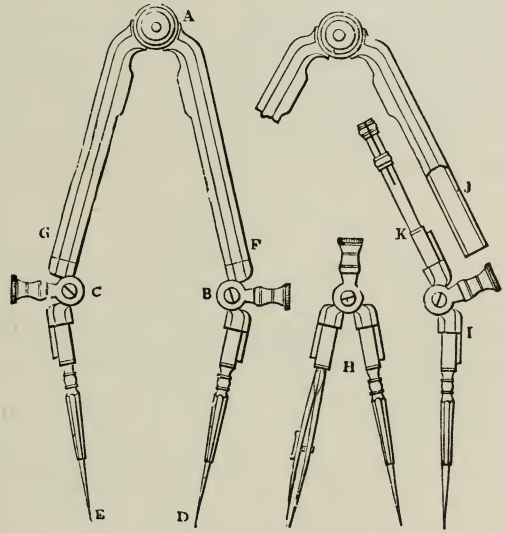
* Messrs. Parkes and Son, of Birmingham, have introduced needle-points to their compasses, which greatly tend to facilitate accuracy in drawing.

limbs can be turned upon these pivots so as to make the points *e* and *g*, or *f* and *h* change places. By this simple and ingenious contrivance, the draftsman, after having used the two fine points *e* and *f*, for fixing with precision the opening of the compass to his required radius, may obtain a pencil point to describe a corresponding arc or circle, by simply turning the pencil limbs *h*, *f*, round on its pivot *d*, which will cause the point of a pencil or crayon placed in the tube *h*, to change places with the fine point *f* of the compasses, and as the pivot is (or ought to be) at right angles to a line connecting the points *f*, and of the pencil at *h*, the latter will exactly take the place of the former, at the same extent or opening, *e*, *f*. In like manner, by turning the pen limb *e*, *g*, round its pivot *c*, the pen point *g* may be made to occupy the position of the fine point *e*, or whatever the compasses may have been set to in the first instance. The milled-head screw, represented at *k*, is for the purpose of fixing a pencil firmly in its tube *h*; the screw *i* is for adjusting the blades of the pen-point *g*, between which the ink is inserted to any required degree of fineness, so as to produce a corresponding fine or coarse circular line. The joint *m*, by removing altogether the screw *i*, gives the means of opening the blades for the better cleansing them after use.

Portable or Turn-in Compasses.

This forms in itself a complete portable case of drawing instruments, consisting of a large pair of compasses with movable points, which are also so contrived that one forms in itself a small pencil bow and the other a pen bow; and when the whole instrument is put toge-

ther and folded up (or the points turned in, from whence is derived the name of *turn-in compasses*) they occupy a space not more than three inches long, and may be carried in the pocket without being an incumbrance. The annexed engraving represents the instrument when all its parts are together. The principal



legs of the instrument are F and G, movable, as usual, by a joint at A. The lower joints, B and C, afford the means of setting the front limbs, D and E, perpendicular to the paper, as explained before when describing the last instrument. Each of the point limbs may be removed from the legs F and G, and by means of their joints B and C form perfect instruments—the one a pen bow, represented at H, and the other a pencil bow, shown at I K. The points of these lesser instruments are all adapted to slide into the principal legs, F and G, of the larger one, which are made hollow for their

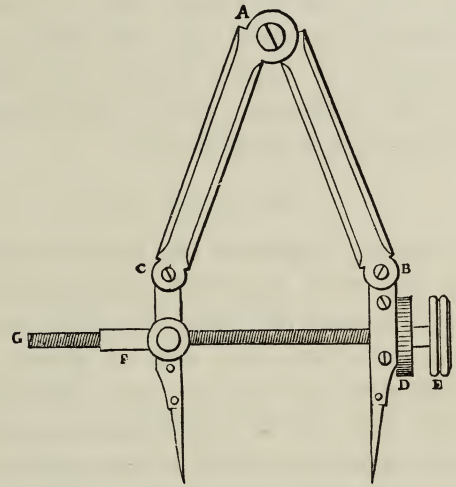
reception. A section of the limb F is shown at J, to convey to the reader a better idea of the arrangement.

It may easily be seen from the engraving, that by reversing either of the points in the principal instrument, the other point may be used as a centre. When not in use the instrument may be conveniently carried in a sheath or case provided for the purpose. There are also various forms and arrangements of the parts occasionally given to the instrument to suit the fancies of individuals; but the one we have described above will give the reader a correct notion of the general character of this class of instruments.

Large Screw Dividers.

We have now to describe another class of compasses, such as are used for accurately dividing lines, &c., into a definite number of equal parts, or for setting off equal distances. The first of these is the large screw divider represented in the adjoining figure: A is the centre, about which the legs A C and A B open or shut; B and C are joints by which the pointed limbs may be set perpendicular as usual. The extent or opening between the points is regulated by a screw passing through a socket, F, and terminated at the other extremity by a milled head, by which the screw is turned round. Between this milled head and the nearest pointed limb is fixed what is called a micrometer head, decimally divided round its outer or cylindrical edge. One turn of the screw carries the micrometer head completely round; therefore, when part of a turn only is given to the screw, the divisions on the head show what fraction of a turn has been given, and if it be known what number of turns or threads of the screw are equal to one inch, the points of

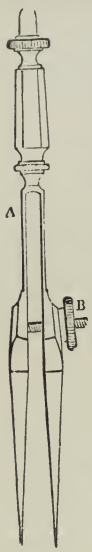
these compasses may be thus set to any small definite measure of length with the utmost precision. The index or zero for reading the fraction of a turn of the screw is marked on the point limb below B: thus this instrument may be considered as a beam compass of small dimensions and minute accuracy.



Spring Dividers.

This instrument, represented in the accompanying diagram, is particularly useful for repeating divisions of a small but equal extent—a practice that has the name of stepping, for which a small pair of hair compasses would also be found useful when the head is constructed as shown in the adjoining figure, or similar to that of the bow compass before described, and for reasons before stated. The upper part forming the handle is composed of brass or silver, whilst the lower part from A towards the points is made of one piece of steel of a spring temper, whereby the two points are

always endeavouring to recede from each other, or open by their elasticity, which is counteracted by the adjusting screw B, by which it may be set to the required opening. This acts in the same manner as the micrometer screw, described as belonging to instruments before explained, but with this difference—that it has not the means of pointing out the measure of the material, or extent between the fine points of the compasses, which must therefore be taken from a suitable scale.



Wholes and Halves.

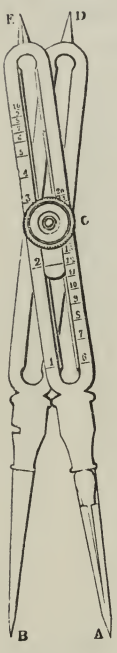
Having explained the general construction of the most approved instruments of the smaller kind for describing circles and dividing lines, we come now to allude to those employed in copying and reducing drawings. And first of the instrument represented in the annexed engraving, which is the simplest form of proportional compasses, and capable of reducing or enlarging in one proportion only—namely, one-half, from whence its name of wholes and halves is derived. The points A and E are one piece of metal: likewise the points B and D are at the extremities of another piece of metal, and straight lines connecting these points pass through the centre, C. The legs of the instrument are connected together by a joint of the usual form at C, placed one-third of the whole length from one extremity: consequently, whatever may be the extent of the opening of the points A and B, it will always be double the extent of the opening of the other two points, D and E. Therefore, if the whole

length of any line be taken between the opening of the two former points, the interval between the two latter points will be exactly one-half the length of the same line; consequently, this instrument affords the readiest means of dividing a line into two equal parts, or *vice versa*. Its usefulness in dividing lines does not rest here; for, if the original line has to be divided into any number of parts—2, 4, 6, 8, &c., by constantly taking the half of the half in the same manner as taking the half of the original line in the first instance, the requisite number of subdivisions may be obtained.

Proportional Compasses.

This instrument is a very useful and necessary appendage to a case of drawing instruments, and although rather expensive in its original cost, it very soon repays its owner in saving both time and trouble. The proportional compasses consist of two equal and similarly formed parts or limbs, A E and B D (see the accompanying engraving), which are represented as opening upon a centre C, and forming a double pair of compasses or points, A B, E D. When shut up, the two limbs appear as one, and a small stud fixed on one fits into a notch made in the other, and retains the instrument exactly in its closed position, the two points also at each extremity then coincide and become as one point. When thus closed the dove-tailed slits shown in the engraving as made in each limb, being equal and similar, coincide and appear as one slit, and in this position only can the

adjustment be made for any required proportion; that is to say, the instrument must always be closed in order to slide and fix the centre C in its proper place, and the opening of the small points E D at the other extremity.



The centre consists of a pivot or steel pin, which passes through the dove-tailed pieces of brass, nicely fitted to slide in the before-named slits, and also through a circular nut or collar on each face, which answers the double purpose of keeping the dove-tailed pieces of brass in their slits, and also firmly clamping them together by means of the milled head, C, when they are moved to the position where the centre is required; on the dove-tailed pieces a line is drawn for the zero to set the centre by, which in our engraving is represented as coinciding with the division on the limb marked 2, and nearly with the one marked 12. On the face of each limb there are two sets of division, one denominated lines, a second circles, a third planes, and the fourth solids. When the zero of the centre on the dove-tailed sliding-piece is set to the division marked 1, on the line of lines, then the proportion between any opening of the large points A B, will be two to one, or twice as great as the opening of the smaller points D E, and consequently any extent taken between the large points may be accurately divided into two parts by the smaller ones. Also when the zero is set to the division marked 3, on the same lines, the proportion of any opening will be three to one, or that of the smaller points will be one-third of the

extent of the larger points, and the same of the remaining divisions on the line which extend to ten of the line marked "*circles*" on the opposite edge of the same face of the instrument; the divisions are numbered from 6 to 20, and the index of zero being set to any number, the points will open in proportion to the radius of a circle to the side of an inscribed polygon of that number of sides. Thus if it be set to the division marked 8, and the points A B are opened to the radius of any circle, the opening of the smaller points D E will divide the circumference into eight equal parts.

The other lines of divisions, namely, those marked "planes" and "solids," are on the other face of the instrument, these are in fact lines of square and cube roots. The line of "*planes*" or "*squares*" shows the proportion between the areas of similar plane figures. Thus, set the zero to the division marked 3, and measure the side of the square in the large points A B, the opening of the short ones, D E, will then be equal to the side of a square, which will be one-third the area of the other. The same of triangles, circles, or any other regular plane figure.

To find the square root of a given number, shut the compasses and set the zero to the number given upon the line of planes, open the instrument, and from any scale of equal parts take the number between the larger points A B, then apply the smaller points D E, to the same scale, and the distance between them will be equal to the square root of the distance between the points of the larger legs A B. The mean proportional between two given numbers is the square root of their product, and may be found by the proportional compasses; thus, required the mean proportional between 2

and $4\frac{1}{2}$. Open the compasses with the zero or index set against 9, the product of two given numbers, till the distance between the larger is equal to 9, taken from some scale of equal parts, then the distance between the smaller points will be equal to 3 of the same scale, and is the mean proportional between 2 and $4\frac{1}{2}$, for as $2 : 3 :: 3 : 4\frac{1}{2}$.

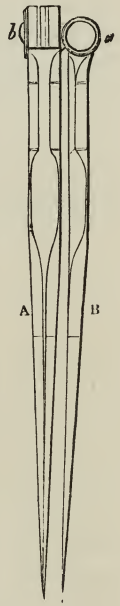
The line of "solids" expresses the proportions between cubes or spheres. Thus, set the zero to the division marked 2 on the line of solids, then measure the diameter of any sphere, or the side of a cube which will have one half the solid content of the former. In like manner, by setting zero to the divisions marked 3, 4, &c., the interval between the larger and smaller points of the instrument will show respectively the diameters, &c., of spheres, of which one shall have three or four times the solid of the other.

Also the cube root of any number may be found by setting zero upon the given number upon the line of solids, &c., as described for obtaining square root by means of the line of planes; proportional compasses of the best construction are sometimes made with a clamp and tangent screw for setting the zero with the utmost precision; this, however, is seldom used, and the instrument we have described is the kind in general requisition.

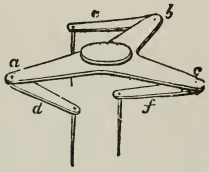
Triangular Compasses.

The adjoining figure represents this instrument as it appears when closed up for packing in its case. That which appears in the engraving as one limb A, consists of a pair of compasses precisely of the ordinary construction; the single point limb B, has a compass joint at *a*, by which its points may be opened at right

angles to the plane of the pair of compasses A, when the three points will form a triangle. The compass point at *a* is firmly attached to the centre of the compasses A, which, by means of a nut or screw *b*, may be turned round without moving the limbs, of which it is the centre. The double motion thus given to the point limb B (both right angles to, and parallel to the plane of the compasses A), partake of the nature of an universal joint, and enables the three points of the instrument to be placed at the angular points of any shaped triangle whatever, be it ever so obtuse. Also, by the same means, the three points may be brought into one straight line. This instrument, it will be obvious from the description, is chiefly useful in transferring points from one paper to another, and is very serviceable in copying mechanical drawings. The two points of the compasses A being set upon such points of the drawing as are already copied, the third point, B, of the instrument may be moved by its universal joint, *a b*, to rest upon any other point, and then by similarly applying the points of A to the corresponding points on the copy, the new point of the original may be correctly transferred to it by means of the limb of the instrument B.



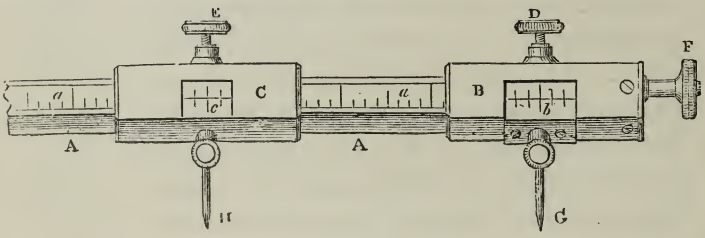
Another form of triangular compasses is represented in the annexed engraving. *a, b, c* is a solid tripod, having at the extremity of each arm a limb, *c, d,* and *c,* moving freely upon centres, by which they may be placed in any position with respect



to the tripod and each other. These limbs carry points at right angles to the plane of the instrument, which may be brought to coincide with any three given points on the original drawing, and then transferred to the copy as above described.

Beam Compasses.

The accompanying diagram represents this instrument, which consists of a beam, A, A, of any length



required, generally made of well-seasoned mahogany; upon its face is inlaid, throughout its whole length, a slip of holly or box-wood, *a*, *a*, upon which are engraved the divisions or scales, either feet and decimals, or inches and decimals, or whatever particular scale may be required: those made for use of the persons engaged on the ordnance survey of Ireland were divided to a scale of chains, 80 of which being equal to six inches, which therefore represented one mile, that being the scale to which the survey is being plotted. Two brass boxes, B and C, are adapted to the beam; the latter may be moved by sliding to any part of its length, and fixed in position by tightening the clamp screw E. Connected with the brass boxes are the two points of the instrument, G and H, which may have any extent of opening by sliding the box C along the beam, and the other box B being firmly fixed at one extremity. The object to be attained in the use

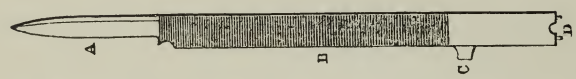
of this instrument is the nice adjustment of the points G and H to any distance apart; this is accomplished by two verniers or reading plates, *b*, *c*, each fixed at the side of an opening in the brass boxes to which they are attached, and afford the means of minutely subdividing the principal divisions, *a*, *a*, on the beam which appear through those openings; D is a clamp screw for a similar purpose as the screw E, namely, to fix the box B, and prevent motion in the point it carries after adjustment to the position; F is a slow-motion screw by which the point G may be moved any very minute quantity, for perfecting the setting of the instrument after it has been otherwise set as nearly as possible by the hand alone.

The method of setting the instrument for use may be understood from the above description of its parts, and also by the following explanation of the method of examining and correcting the adjustment of the vernier *b*, which, like all other mechanical adjustments, will occasionally get deranged; this verification must be done by means of a detached scale. Thus, suppose for example that our beam-compass is divided into feet, inches, and tenths, and subdivided by the vernier to hundredths, &c. First set the zero division of the vernier to the zero of the principal divisions on the beam, by means of the slow-motion screw F. This must be done very accurately. Then slide the box C with its point G, till the zero on the vernier C exactly coincides with any principal division on the beam, as 12 inches or 6 inches, &c., which must also be done to a great nicety (in some superior kind of beam-compasses the box C is also furnished with a tangent or slow-motion screw, by which the setting of the points or the divisions may be done with the utmost

precision in the same manner as the vernier *b*, by means of the screw F), then apply the points to a similar detached scale, and if the adjustment is perfect the interval of the points G H will measure on it the distance to which they were set on the beam. If they do not by ever so small a quantity, it should be corrected by turning the screw F till the joints exactly measure that quantity on the detached scale: then, by loosening the little screws which confine the vernier *b* in its place, the position of the vernier may be gradually changed till its zero coincides with the zero on the beam, and then, tightening the screws again, the adjustment will be complete.

Knife, File, Key, and Screw-driver.

The annexed engraving represents a very useful appendage to a case of drawing instruments; its use will

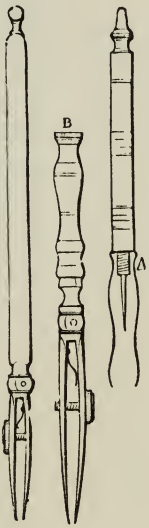


be too apparent to need much description. A is the knife blade, B the file, C the screw-driver, and D the key, which is adapted to fit the heads of the compasses for tightening or loosening them as may be required.

Drawing Pens.

These are made as represented in the accompanying engraving. The left-hand figure shows the form of the best kind, the handle is of ivory, and the blades have a joint whereby they may be opened for the purpose of more effectually cleaning them after use. The right-hand figure, which is in two parts, shows an older form of construction, the part A, to which is attached a pricker or protracting pin, screws into the part

marked B, making the handle of sufficient length to use conveniently as a drawing pen, thus combining two instruments in one.



The milled head screw, which is represented as connecting the blades together, is for the purpose of setting their points at any opening to draw a line of an assigned thickness. In using the pen, it should be slightly inclined in the direction of the line to be drawn, taking care, however, that the edges of both the blades touch the paper. These observations are equally applicable to the pen-point of the compasses before described, observing, as before stated, that whenever a circle or an arc of more than about an inch radius is to be described, the point should be so bent that the blades of the pen be nearly perpendicular to the paper, and both of them touched at the same time.

The Road Pen.

This instrument consists of two pens, A and B, so arranged with a spring which gives them a tendency to separate from each other to the extent of about half an inch, which tendency is counteracted by a screw, C, whereby the pen-points may be set to any required interval within the above limits. The screws *a* and *b* are for the purpose of setting the points of the blade to draw lines of any assigned degree of fineness, as before explained for the ordinary drawing pen. The use of this instrument is to draw two lines parallel and close to each other at the same time, whereby perfect paral-

lelism may be secured. It is usually known by the name of the Road Pen, having been originally designed to draw lines of roads upon maps, both sides being drawn at the same time. For such purposes it is very convenient, as one side or fence may be drawn with a stronger line than the other, which is frequently done on general maps as a distinguishing mark for principal or turnpike roads, &c. In like manner it is useful in drawing lines of canals, where bounding lines are generally more nearly parallel than on public roads; besides which, it may be successfully used in mechanical and architectural drawings, where extremely close parallel lines are very frequently required.

The Dotting Point.

The great expense of time in dotting by hand such lines upon a drawing as may be essential to be shown and not drawn in full, may be obviated by the use of this instrument. It in all respects resembles a drawing-pen, except that the points are not so sharp, and the back blade, as seen in the engraving, is a pivot, on which may be placed a dotting-wheel, *a*, resembling the rowel of a spur; the screw, *b*, is for opening the blades to remove the wheel for cleaning after use, or replacing it with one of another character of dot. The cap, *c*, at the upper end of the instrument, is a box containing a variety of dotting wheels, each producing a different shaped dot. These are used as distinguishing marks for different classes of boundaries on maps; for instance, one kind of dot distinguishes *county*

boundaries, another kind *parish* boundaries; a third kind distinguishes that which is both a county and a parish boundary. In using this instrument, the ink must be inserted between the blades of the dotting wheel, so that as the wheel revolves the points shall pass through the ink, each carrying with it a drop, and marking the paper as it passes. It is sometimes stated as an objection, that the wheel will often revolve many times before it begins to deposit its ink on the drawing, thereby leaving the first part of the line altogether blank, and in attempting to go over it again, the made dots are liable to get blotted; at all events, the line is likely to consist of dots of different sizes, which is at least unsightly. This evil may be mostly remedied by placing a piece of blank paper over the drawing at the very point the dotted line is commenced upon; then begin with drawing the wheel over the blank paper first, so that by the time it will have arrived at the proper point of commencement, the ink may be expected to flow over the points of the wheel, and make the dotted line perfect, as required.

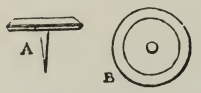
The Pricking or Tracing Point.

This instrument consists of a pair of forceps, which firmly hold a needle point, or blunt point, *a*, by means of a sliding ring, *b*. Its use, which scarcely needs pointing out, is chiefly in copying drawings, the original being laid upon paper intended to receive the copy, and held down by weights or pins to prevent its shifting its position. The principal points are trans-

ferred to the copy by pricking through the original with a very fine needle. This method of copying cannot be resorted to when the original is of considerable value. When such is the case, a common method of copying is by placing between the drawing and the intended copy a sheet of thin paper (such, for instance, as bank post paper), one face of which has been sprinkled with black lead and rubbed until it be uniformly covered, and then as much wiped off as would come away with gentle rubbing. This being placed with the blackened part towards the intended copy, a blunt point substituted for the needle point in the instrument may be drawn with gentle pressure over the lines of the original without damaging it, and the blackened paper will leave corresponding lines on the fair sheet beneath; by reversing the needle in the instrument, leaving the eye end instead of the point exposed, and using it edgeways, it will be found a fine and smooth tracer.

Drawing Pins.

These require but little explanation. They are used to fix paper down upon a drawing or other board in any required position, and in most cases answer better than heavy weights, which are frequently used for that purpose, as the board may be shifted from place to place without moving the paper. They consist of a brass head with a steel point at right angles to its plane. A represents it as seen edgeways, and B as seen from above.



Having endeavoured to explain the construction of such instruments as are used for the purpose of drawing lines, whether straight or curved, and hence producing geometrical figures, we will now proceed to explain the best form of protractors which are essential for laying down angles.

Protractors.

The edge of the semicircular is divided into 180 degrees, and subdivided to half degrees, or 30 minutes, and numbered for the convenience of plotting. Round the edge is carried a vernier, which subdivides the principal divisions into single minutes. The vernier is attached to an arm, forming a radius to the semicircle, which is extended beyond the circumference, and has on the extended part a fiducial edge, on which the angular line is to be drawn.

The centre of the instrument, which is visible from above, by the centre upon which the vernier radius moves, is a ring placed concentric with the centre. To use this instrument, it is only necessary to set the vernier to the given angle, then place the protractors so that the fiducial edge may in every part exactly coincide with the line already given, and the centre with the given angular point. A line then being drawn along the fiducial edge will be the direction of the line forming the angle required; and upon moving the protractor, such line may be produced and connected with the angular point. In adjusting the fiducial edge upon the given line, so that the centre may exactly coincide with the given angular point, there is a certain degree of practical difficulty (we are now alluding to whenever great accuracy is aimed at).

It is not, therefore, essential, in setting the instrument, to have any regard to the given angular point, but only to set the edge nicely upon the given line; then, with a needle point, make three punctures in the paper, one near the extreme point, a second at the circumference of the arc, and the third as nearly as possible at the centre. The protractor may then be removed; and if all has been accurately performed, these three points will be in one straight line, which may be transferred to pass through the given angular point by straight edge or ruler.

The Circular Protractor

Is a complete circle, connected in its centre by four radii. Like the instrument last described, the centre is left open, and surrounded by a concentric ring or collar, which carries two radial bars. To the extremity of one bar is a pinion, working in a toothed rack, quite round the outer circumference of the protractor. To the opposite extremity of the other bar is fixed a vernier, which subdivides the primary divisions on the protractor to single minutes, and, by estimation, to 30 seconds. This vernier, as may readily be understood, is carried round the protractor by turning the pinion. Upon each radial bar is placed a branch, carrying at their extremities a fine steel pricker, whose points are kept above the surface of the papers by springs placed under their supports, which give way when the branches are pressed downwards, and allow the points to make the necessary punctures in the paper. The branches are attached to the bars with a joint, which admits of being folded backwards over

the instrument when not in use, and for packing in its case.

The centre of the instrument is represented by the intersection of two lines, drawn at right angles to each other on a piece of glass, which enables the person using it to place it so that the centre, or intersection of the cross lines, may coincide with any given point on the plane. If the instrument is in correct order, a line, connecting the fine pricking points with each other, would pass through the centre of the instrument, as denoted by the before-mentioned intersection of the cross lines upon the glass, which, it may be observed, are drawn so nearly level with the under surface of the instrument as to do away with any serious amount of parallax when setting the instrument over a point from which any angular lines are intended to be drawn.

In using this instrument, the vernier should first be set to —*zero* (or the division marked 360), on the divided limb, and then placed on the paper, so that the two fine steel points may be on the given line (from whence other and angular lines are to be drawn), and the centre of the instrument coincides with the given angular point on such line. This done, press the protractor gently down, which will fix it in position by means of very fine points on the under sides. It is now ready to lay off the given angle, or any number of angles that may be required, which is done by turning the pinion till the opposite *vernier* reaches the required angle. Then press down the branches, which will cause the points to make punctures in the paper on the opposite sides of the circle; which being afterwards connected, the line will pass through the given angular point, if the instrument was first correctly set. In

this manner, at one setting of the instrument a great number of angles may be laid from the same point.

As described for the last instrument, it is not essential that the centre be over the given point when applied to the given line, provided the pricking points exactly fall upon the line; for an imaginary line, connecting the pricking points in this instrument, correspond with the line on the diameter of the protractor last described. Sometimes, instead of a rack and pinion motion, a third radial arm is attached to the centre at right angles to the other two, upon which is fixed a clamp and tangent screw, by which the vernier is not only fixed in position upon the circular limb of the instrument, but by the tangent, or slow motion screw, it may be set to the required angle with the greatest accuracy.

Plain, Circular, and Semicircular Protractors.

Other and very useful protractors are made, consisting of a circle or semicircle, without verniers, slow-motion screws, or any other appendages, having simply a fiducial circular edge, nicely divided to degrees and half-degrees, or more minute subdivisions, if the instrument is sufficiently large to admit of them. A very useful instrument of this kind has a diameter of six inches, and will be found sufficiently accurate for most ordinary purposes, and not above one-third of the cost of the above-named instrument, which, however, must be resorted to when the utmost attainable accuracy is required.

The Plain Scale.

This instrument is usually made of ivory, 6 inches long, and 1¾ inches broad; it has on it two diagonal

scales, one half the size of the other, on the same plane or face of the instrument, which, for distinction-sake, we will call the upper side. These diagonal scales consist of eleven parallel lines, drawn equi-distant from each other, and divided by vertical lines into equal parts of an inch long, and numbered from right to left—1, 2, 3, &c. The top and bottom lines of the extreme half-inch space to the right is subdivided into ten equal parts by diagonal lines drawn from the tenth below to the ninth above, from the ninth below to the eighth above, from the eighth below to the seventh above, &c., till from the first below to the nothing above, so that by these means the half-inch space is subdivided into 100 equal parts. Thus, if each of the first divisions of the half-inch spaces be considered to represent unity, each of the first divisions will express $\frac{1}{10}$ of 1, and each of the subdivisions taken on the diagonal lines, counting from the top downwards, will express $\frac{1}{10}$ of the last subdivisions, $\frac{1}{100}$ of the half-inch spaces (or primary divisions). If each of the half-inch spaces (or primary divisions) be considered as representing 10, then each of the first subdivisions will express 1 (or unity), and each of the second $\frac{1}{10}$ of unity. Again, if each of the primary divisions (or half-inch spaces) be considered to represent 100, then each of the first subdivisions will express 10, and each of the second subdivisions 1, or unity, &c., &c.

The method of taking distances from the scale may be thus shown :—Suppose the distance to be 347 on the diagonal, lined, joined to the 4th subdivision on the top line, count 7 downwards, reckoning the distance of each parallel as 1 ; there set one point of the compasses, and extend the other till it falls on the inter-

section of the third primary division with the same parallel in which the other point of the compasses rests, and their opening will then express a line of 347, 34·7, or 3·47, according as we may have considered the primary divisions to represent 100, 10, or unity.

The smaller diagonal scale is formed by dividing the half-inch space into two, and the further or left-hand quarter of an inch space is then diagonally divided as above described.

On the same or upper face of the instrument, a protractor is formed round its edges, and after what has been stated upon that instrument, nothing more than the mention of it is requisite in this place. On the under surface of the instrument a variety of scales are engraved, among which are the following:—

Line of	Chords	marked	C or C H.
„	Rhombs	„	R H.
„	Tangents	„	T A.
„	Sines	„	S I.
„	Secants	„	S E C.
„	Longitudes	„	L O N.
„	Latitudes	„	L A.
„	Inclination of Meridians	„	I M.
„	Hours	„	H O.

Besides scales having the following number of equal divisions to the inch:—30, 35, 45, 50, and 60.

The line of chords serves either to set off an angle from a given point to any line, or to measure the quantity of any angle already laid down. The first is done by opening the compasses to the extent of 60 degrees upon the line of chords (which is always equal to the radius, the circle of projection), and set-

ting one foot upon the angular point; with that extent describe an arc; then taking the angular quantity from the same chord line, set it off from the given line upon the arc described; a right line connecting the given point with that upon the arc will form the angle required. To measure an angle already laid down, describe as before an arc of 60 degrees; and then taking the extent with a pair of compasses between the lines which form the angle upon the said arc, the opening measured upon the same line of chords will denote the dimensions of the angle.

The line of rhombs serves to lay down or measure on a chart the angle of a ship's course in navigation.

The lines of tangents, sines, and secants, are used in the stereographical and orthographical projection of the sphere.

The line of longitudes, with the help of the line of chords, will show how many miles are contained in a degree of longitude at any latitude. Thus, with a pair of compasses take from the line of chords the number of degrees of the given latitude, and apply the opening of the compasses to the line of longitude, placing one point of the compasses on the last division, marked 60 on the longitudes, the other point will note upon the same line the number of miles in one degree of longitude at the given latitude. For example, if the given latitude be 60 degrees, take 60 from the line of chords, and applying one point of the compasses on the last division of the line of longitude (marked 60), the other point will fall upon the division marked 30 on the same line, showing that 30 miles is contained in one degree of longitude at the latitude of 60 degrees. The lines of latitude, inclination of meridian, and of hours, are

applicable to the practice of dialling, which does not fall within our present purpose.

Plotting Scales and Rules.

These need but few observations, as they are nothing more than scales of equal parts, the divisions being placed on a fiducial edge, by which any length may be pricked off on the paper without using the compasses, whose points, by frequent use, destroy the fineness of the graduation. Plotting scales are made of various dimensions, and of all varieties of graduation, to suit the purposes of the draftsman. Parallel rulers are also made of various constructions—some of them sliding, and others with rollers, each having its own advantages. The plain scale above described is frequently fitted with rollers, making it at the same time a convenient small parallel.

The Sector.

The sector derives its name from the fourth proposition of the sixth book of Euclid, where it is demonstrated that similar triangles have their like sides proportional.

This instrument consists of two rulers, movable round an axis or joint, from whence several scales are drawn on the faces of the rulers.

The two rulers are called legs, and represent the radii, and the middle of the joint expresses the centre of a circle.

The scales generally put upon sectors may be distinguished into single and double. The single scales are such as are commonly put on plain scales, and may be applied in the same manner. The double scales are

those which proceed from the centre; each scale is laid twice on the same face of the instrument, namely, one on each leg. From these scales, dimensions or distances are to be taken, when the legs of the instrument are in an angular position.

The Decimal Scale.

This scale lies on the edge of the instrument, and is of the same length as the sector when opened (one foot is the usual length for sectors placed in cases of instruments), and is divided into 10 equal parts or primary divisions, and each of these into 10 other equal parts, so that the whole (foot) is divided into 100 equal parts.

The Line of Artificial Numbers.

The line of numbers (marked N), or Gunter's Line, as it is commonly called, is a line of geometrical proportion divided into nine unequal parts, beginning at 1 towards the left hand, and numbered on with 2, 3, 4, 5, &c., to 10, about the middle of the line, where another radius begins, and the same divisions are repeated, numbered as before to 10, at the end of the line on the right hand. Each of these primes, or first grand divisions, are subdivided, according to the same ratio, into ten other parts, and each of these divisions (if the line be of sufficient length) should again be subdivided into ten lesser parts. But upon pocket sectors, which, when opened, are twelve inches in length, only the part from 1 in the middle to 2 towards the right hand is a second time divided, and that but into five parts instead of ten, every one of which must be accounted as two centesms in numbering; therefore, upon the

line the figures 1, 2, 3, &c., which denote the primes, may be taken arbitrarily, either as units, tens, hundreds, or thousands, or thousandth parts of an unit.

If 1, at the beginning of the line, be taken for unity, then 1 in the middle will be 10, and 10 at the end 100; but if the first 1 be accounted 10, then 1 in the middle will stand for 100, and 10 at the end for 1000. Again, if the first 1 be reckoned 100, then 1 in the middle will be 1000, and 10 at the end 10,000.

When, therefore, the first, or prime, represents 10 units, the figures 2, 3, 4, &c., to 1 in the middle, will stand for 20, 30, 40, &c.; and each tenth, or subdivision in the first radius of the line, will signify 1 unit; and each centesm in those tenths (if there be any) will be one-tenth part of an unit: 1 in the middle will be (as before observed) 100; and the figures 2, 3, 4, &c., following, 200, 300, 400, &c.; each tenth, or subdivision in the second radius, will denote 10 units; and each centesm 1 unit. Again, let the first 1 represent 100, then the 2, 3, 4, &c., following, 200, 300, 400, &c.; 1 in the middle 1000; and 10 at the end 10,000. According to this supposition, in the first, each tenth of a prime will be 10 units, and each centesm 1 unit; and in the second radius, each tenth of a prime 100, and each centesm 10.

In estimating decimal fractions upon the line, if 1 in the middle be accounted as unity, then will each prime in the first radius denote ·1, each tenth of a prime ·01, and each centesm ·001. If 10 at the end of the line to the right hand be accounted as unity, the whole first radius will represent 1, and 2, 3, 4, &c., in the second radius will represent 2, 3, 4, &c., every prime in the first radius, and every tenth of a prime in

the second radius, will signify ·01, or one hundredth part of unity, or centesm; in the second, will denote ·001, or thousandth part of unity.

The numeration of the line thus explained, let it now be proposed to find the point thereon, answering to the number 436. For four hundred, take the first four primes next the left hand; for the second figure, 3, take three tenths of the grand division between 4 and 5; and for the six units, reckon six centesms, or six parts of the next tenth, so that the extent from 1 at the beginning of the line to that point, will express the number 436. The same point will likewise represent the numbers 43·6, 4·36, or 436; if the first be accordingly accounted 10, 1, or $\frac{1}{10}$ of unity.

To multiply upon the line, extend your compasses from 1 at the beginning, to the point representing the number of your multiplier. The same extent will reach from the number of your multiplicand to the product. Thus, if 125 were given to be multiplied by 42, extend the compasses from 1 to 42, and the same extent will reach from 125 to 5250.

To divide upon the line, extend your compasses backwards from the numbers of the division to unity. The same extent, laid the same way, will reach from the number of the dividend to the quotient. Thus, if 5250 were to be divided by 125, extend the compasses backwards from 125 to unity; the same extent will reach the same way, from 5250 to 42.

The Lines of Artificial Sines and Tangents.

The line of artificial sines (marked s) consists only of the logarithms of the natural sines, transferred from a

table of logarithms to the scale. They are numbered from the left to the right, with the figures 1, 2, 3, &c., to 10, which stands about the middle of the line; and so forward with 20, 30, 40, &c., to 90, at the end on the right. In the first part of the line, the grand divisions each represent one degree; so that if each prime be subdivided into twelve parts (as they are commonly called upon sectors), each subdivision will represent five minutes. In the latter part of the line, the grand divisions, which are each ten degrees, being subdivided into ten parts, each of them will signify five minutes. In the latter part of the line the grand divisions, which are each ten degrees, being subdivided into ten parts, each of them will represent one degree; and according as they are again subdivided into four, three, or two parts, such second divisions contain fifteen, twenty, or thirty minutes each.

What has been stated of the line of sines is likewise to be understood of the line of artificial tangents, (marked T), whose divisions begin also at 1, and run on to 10 in the middle of the line, signifying degrees. In the second part it runs on with 20, 30, &c., to 45, which stands at the end of the line; then returns back again to 90, where it began.

The use of these lines is in working proportions, whether arithmetical or geometrical, as well as in trigonometrical solutions. Thus, in all proportions, three terms are given to find a fourth. Seek out, therefore, the first term, whether number, sine, or tangent, on its proper line; and in that point set one foot of the compasses, and extend the other to the second or third term, whichever of them is of the same name as the first; the same extent laid from the other term the same way will reach to the fourth term required.

Example.—As the sine of 52°. 30′ : 85 :: radius, or the sine of 90° to the fourth number required.

Set one foot of the compasses in the line of artificial sines on 52°. 30′, and extend the other foot to 90° on that line; the same extent will reach from 85 on the line of numbers to 107, the fourth term required.

The Double Scales.

These consist of the line of lines. or of equal parts marked L; the line of chords marked C; the line of sines marked S; the line of secants also marked S, but placed on the reverse side of the sector; the line of polygons marked Pol; a line of tangents to 45° marked T; and also a second line of tangents from 45° to 75°. Each of these scales begins at the centre of the instrument, and is terminated near the other extremity of each leg; viz. the lines at 10, the chords at 60, the sines at 90°, and the tangents at 45°; the remainder of the tangents, or those above 45°, are on other scales beginning at $\frac{1}{4}$ of the length of the former, counted from the centre, and marked with 45, and run to about 76 degrees.

The secants also begin at the same distance from the centre, where they are marked with 10, and are continued to as many degrees as the length of the sector will allow, which is about 75°.

The angles made by the double scales of lines of chords, of sines, and of tangents to 45 degrees, are always equal.

The angles made by the scales of upper tangents, and of secants, are also equal, and sometimes these angles are made equal to those made by the *other* double scales.

The scale of polygons is put near the inner edge of the legs; their beginning is not so far removed from the centre as the 60 on the chords is. The beginning of this scale is marked 4, and from thence is figured towards the centre of the instrument to 12.

From this disposition of the double scales, it is plain that those angles which are equal to each other when the legs of the sector are close, will continue equal to each other at every opening of the instrument.

Method of using the Double Lines on the Sector.

When a measure is taken on any of the sectoral lines beginning at the centre, it is called a lateral distance; but when a measure is taken from any point on one line, to its corresponding point on the line of the same denomination on the other leg, it is called a transverse distance.

The divisions of each sectoral line are contained within three parallel lines, the innermost being the line on which the points of the compasses are to be placed, because this is the only line of the three which goes to the centre, and is therefore the sectoral line.

Line of Lines.

Multiplication.—With the compasses, take from any convenient distance from the scale of equal parts the length of one of the factors, and open the sector until the transverse distance between 10 and 10 is equal to it; then the transverse distance of the other factor (*measured upon the same scale of equal parts*) will represent the product.

Example.—Multiply 4 by 5, expand the compasses from the centre of the sector to 4 on the primary divisions (*or take it from any other scale of equal parts*), and

open the sector till this division becomes the transverse distance from 10 to 10 on the same divisions; then the transverse distance from 5 to 5, measured upon the same scale as the former, will equal 2 or 20, the answer.

Division.—Make the lateral distance of the dividend the transverse distance of the divisor; the transverse distance of 10 will be the quotient.

Example.—Divide 20 by 4. Make 20, taken from any convenient scale of equal parts, the transverse distance of 4, then the transverse of 10 (measured upon the same scale) will be 5, the answer.

It will readily be perceived for the multiplication or division of high numbers, aliquot parts of both factors must be taken, and the result multiplied by the same. The application of the sector to such common arithmetical operations is therefore very limited (and of doubtful utility).

Proportion.—Two lines being given to find a third proportional.

Example.—The given = 2 and 6, a third proportional required. Take between the compasses the lateral distance of the second term 6 (either from the line of lines on the sector, or any convenient scale), and open the sector until this distance becomes the transverse distance to the first term 2, then the transverse distance of the second term 6 measured upon the same scale as the former, will equal 18, the third proportional required.

If the legs of the sector will not open so far as to let the lateral distance of the second term fall between the divisions expressing the first term, then take $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, or any aliquot part of the second term (such as will con-

veniently fall within the opening of the sector), and make such part the transverse distance of the first term; then, if the transverse distance of the second term be multiplied by the denominator of the part taken of the second term, the product will give the third proportional required. Thus, in the above example, take $\frac{1}{3}$ of $6 = 2$, which make the transverse distance of 2 the first term; then the transverse distance of 6 the second term will be $= 6$, which multiplied by 3, will give 18, the answer.

Three lines being given to find a fourth proportional, open the sector until the lateral distance of the second term, or some aliquot part thereof, becomes the transverse section of the first term, or some aliquot part thereof becomes the transverse distance of the first term; then the transverse distance of the third term will be the fourth proportional required, or such a submultiple thereof as was taken of the second term.

Example.—To find a fourth proportional to the numbers 2, 6, and 10.

Take this lateral distance of the second term 6 from any convenient scale of equal parts, and open the sector until that quantity, or any aliquot part thereof, becomes the transverse distance of the first term 2, then the transverse distance of the third term 10, taken from the same scale of equal parts, will give 30, the fourth proportional required.

To diminish a Line in any Assigned Proportion.

Example.—Let it be required to diminish a line of 4 inches in the proportion of 8 to 7. Open the sector until the transverse distance of 8 is equal to a lateral distance of 7.

Mark the point where 4 inches will reach as a lateral distance taken from the centre, which will be in this case 6·86, and the transverse distance taken at the point will be 3 inches and a half, the proportion required, that is, 8 : 7 : : 4 : $3\frac{1}{2}$.

We may remark, once for all, that in all problems with the sector, if any given line is too long for the legs of the instrument, take $\frac{1}{2}$, $\frac{1}{3}$, or $\frac{1}{4}$, &c., of it, and the result multiplied by 2, 3, or 4, will give the quantity required.

The use of the sector in reducing drawings may be thus shown :—Suppose a triangle was to be reduced to the proportion of 4 to 7.

Take the length of one side of the triangle in the compasses, and make it the transverse distance of 7 and 7; then take the transverse distance 4 and 4, which will be the length of the corresponding side of the reduced triangle. Next take the length of another side of the given triangles, and make the transverse distance of 7 and 7 as before. Then the transverse distance of 4 and 4 will be the length of the corresponding side of the reduced triangle; one point of the compasses being placed at the proper extremity of the first reduced line, describe an arc with the length of the second line as *radius*. Lastly, the third side of the given triangle being made the transverse distance of 7 and 7, and that of 4 and 4 being taken, another arc intersecting the former one, described from the opposite end of the first reduced line, will give the point to be connected with each end of the first reduced line, and the triangle will be completed.

In the same manner, any right-lined figure, of how many sides soever, may be reduced in any given proportion or augmented by the same rule.

To divide a given line into any proposed number of equal parts:—

Make the length of the given line the transverse distance to the figures representing the number of parts required; then the transverse distance of 1 and 1 will divide the given line as required.

Example.—Suppose a line to be divided into 9 equal parts, take the length of the given line in the compasses, and open the sector until it becomes the transverse distance between 9 and 9; then the transverse of 1 and 1 will be $\frac{1}{9}$th part of the given line, or such a sub-multiple of the $\frac{1}{9}$th part as was taken of the given line. Or the $\frac{1}{9}$th part will be the difference between the given line and the transverse distance 8 and 8.

The latter of these methods is to be preferred when the parts required fall near the centre of the instrument.

To make the line of lines represent any scale of equal parts for drawing, plans, elevations, &c. Thus, suppose a scale of one to five chains, or one inch to five feet were required. Take one inch in the compasses, and, by opening the sector, make it the transverse distances of 5 and 5, and then the transverse distance of any other corresponding points, as 6 and 6, $7\frac{1}{2}$ and $7\frac{1}{2}$ will be that number of chains, and links or feet, &c., to the scale required.

Line of Chords.

The double scales of chords upon the sectors are more generally useful than the single line of chords described on the plane scale: for, on the sector, the radius with which the arc is to be described may be of any length, between the transverse distance of 60 and

of 60, when the legs are close, and that of the transverse of 60 and 60 when the legs are opened as far as the instrument will admit of. But with the chords on the plane scale, the arc described must be always of the same radius.

To protract or lay down a right-lined angle, which shall contain a given number of degrees, suppose 46°.

Case 1.—When the angles contain less than 60 degrees, make the transverse distance of 60 and 60 equal to the length of the radius of the circle, and with that opening describe an arc. Take the transverse distance of the given degrees 46, and lay this distance on the arc. From the centre of the arc draw two lines, each passing through one extremity of the distance laid on the arc, and these two lines will contain the angle required.

Case 2.—When the angle contains more than 60 degrees. Suppose, for example, we wish to form an angle containing 148 degrees. Describe an arc, and make the transverse distance of $\frac{1}{2}$ or $\frac{1}{3}$, &c., of the given number of degrees, and lay this distance on the arc twice or thrice. Draw two lines connecting them, and they will form the angle required.

When the required angle contains less than 5 degrees, suppose $3\frac{1}{2}$, it will be better to proceed thus with the given radius, and from the centre describe an arc, and from a given point lay off the chord of 60°, which suppose to give the point A; and also from the first point lay off in the same direction the chord of $56\frac{1}{2}$ degrees ($=60°-3\frac{1}{2}°$), which would give the point B; then through these two points draw lines to the point A, and they will represent the angle of $3\frac{1}{2}$ degrees, as required. From what has been stated about the pro-

tracting of an angle to contain a given number of degrees, it will easily be seen how to find the degrees or measure of an angle already laid down.

Line of Polygons.

The line of polygons is chiefly useful for the ready division of the circumference of a circle into any number of equal parts from 4 to 12, that is, as a ready means to inscribe regular polygons of any given number of sides from 4 to 12, within a given circle. To which set off the radius of the given circle (which is always equal to the side of an inscribed hexagon), as the transverse distance of 6 and 6 upon the line of polygons. Then the transverse distance of 6 and 6 upon the line of polygons. Then the transverse distance of 4 and 4 will be the side of a square; the transverse distance between 5 and 5, the side of a pentagon; between 7 and 7, the side of a heptagon; between 8 and 8 the side of an octagon; between 9 and 9, the side of a nonagon, &c.; all of which is too plain to require an example.

If it be required to form a polygon upon a given right line, set off the extent of the given line as a transverse distance between the points upon the lines of polygons, answering to the number of sides of which the polygon is to consist, as for a pentagon between 5 and 5, or for an octagon between 8 and 8; then the transverse distance between 6 and 6 will be the radius of a circle whose circumference would be divided by the given line into the number of sides required.

The line of polygons may likewise be used in describing, upon a given line, an isosceles triangle, whose angles at the base are each double that at the vertex.

For, taking the given line between the compasses, open the sector, till the extent becomes the transverse distance of 10 and 10, then the transverse distance of 6 and 6 will be the length of each of the two equal sides of the isosceles triangle.

All such regular polygons, whose number of sides will exactly divide 360 (the number of degrees into which all *circles* are supposed to be divided) without a remainder, may likewise be set off upon the circumference of a circle by the line of chords. Thus, take the radius of the circle between the compasses, and open the sector till that extent is the transverse distance between 60 and 60 upon the line of chords; then having divided 360 by the required number of sides, the transverse distance between the numbers of the quotient will be the side of the polygon required. Thus for an octagon, take the distance between 45 and 45: and for a polygon of 36 sides, take the distance between 10 and 10, &c.

Lines of Sines, Tangents, and Secants.

Given the radius of a circle (suppose to two inches); required the sine and tangent of 28°. 30′ to the radius.

Open the sector so that the transverse distance of 90 and 90 on the sines, or of 45 and 45 on the tangents, may be equal to the given radius, viz. two inches; then will the transverse distance of 28°. 30′, taken from the sines, be the length of that sine to the given radius; or if taken from the tangents, will be the length of that tangent to the given radius. But if the secant of 28°. 30′ was required, make the given radius of two inches a transverse distance of 0 and 0, at the begin-

ning of the line of secants, and then take the transverse distance of the degrees wanted, viz. 28°. 30'.

A tangent greater than 45 degrees (suppose 60) is found thus:—

Make the given radius, suppose two inches, a transverse distance to 45, and 45 at the beginning of the scale of upper tangents, and then the required degrees (60) may be taken from the scale.

Given the length of the sine, tangent, or secant of any degrees, to find the length of the radius to that sine, tangent, or secant.

Make the given length a transverse distance to its given degrees on its respective scale. Then,

If a sine If a tangent under 45° If a tangent above 45° If a secant	the transverse distance of	90 and 90 on the sines 45 and 45 on the tangents 45 and 45 on the upper tangents 0 and 0 on secants.	will be the radius sought.

To find the length of a versed sine to a given number of degrees, and a given radius.

Make the transverse distance of 90 and 90 on the sine, equal to the given radius.

Take the transverse distance of the complement of the given number of degrees.

If the given number of degrees is less than 90, subtract the complement of the sine from the radius, the remainder will be the versed sine.

If the given number of degrees are more than 0, add the complement of the sine to the radius, and the sum will be the versed sine.

To open the legs of a sector, so that the corresponding double scale of lines, chords, sines, tangents, may make each a right angle.

On the line of lines, make the lateral distance 10, a

transverse distance between 8 on one leg, and 6 on the other leg.

On the line of sines, make the lateral distance 90, a transverse distance 45 to 45 ; or from 40 to 50 ; or from 30 to 60 ; or from the sine of any degrees to their complement.

On the line of tangents make the lateral distance of 45 a transverse distance between 30 and 30.

Having now endeavoured to describe the principal drawing instruments in general use, and the principal scales from which all others emanate, we propose at some future period to exemplify the simplicity of their application to all the trades engaged in the building art, accompanied by some useful diagrams and geometrical problems.

CHAPTER VI.

SPECIFICATIONS :—ARTIFICERS' WORK, AND QUANTITIES.

HAVING thus conveyed some preliminary notions as to the methods of designing architectural structures upon paper, and having also described the several materials and trades with their chief tools and methods of manipulation, which are employed in the construction of dwelling houses, we proceed to illustrate the design itself, which will be done most briefly by giving (with the necessary illustrations) an example in the following—

"SPECIFICATION of the different Artificers' Work required for the erection of two houses proposed to be erected on a plot of ground, situate

for

according with, and corresponding to the various drawings, comprising plans, elevations, sections, and details, made and combined with this specification for the purpose of such erection, and under the superintendence of .

CARCASS OF BUILDING."

EXCAVATOR.

The ground is to be excavated to the whole of the extent of the principal building for the basement storey,

and to the depth and dimensions shown, and described on the plans and section, Plates II. and III., which will average an area of about 50 feet by 50 feet, and 5 feet deep; and the trenches then to be dug out of sufficient breadth and depth for the construction of the foundations of the several walls, chimney breasts, piers for sleepers, &c. To excavate when and where directed, according to the dimensions, the earth required for the formation of the rain-water tank, being about 11 feet long, 8 feet deep, and 8 feet wide, as well as for all pipes, drains, traps, syphons, or cesspools, that are, or may be hereafter, described or necessary.

To fill in and well ram the earth or soil round all the foundations, piers, traps, gullies, syphons, &c., and to well puddle round and about the rain-water tank, sufficient to prevent the ingress or egress of water. To level all grounds and to cart away from time to time, as may be directed, all the superfluous earth or rubbish that accumulates round or in the buildings or grounds during their erection, and to leave them in a clean and perfect condition at the conclusion of the works.

BRICKLAYER.

Drains.

Provide and lay six-inch glazed earthenware socket-jointed pipes, for conveying soil and waste-water into principal drain or sewer, in the position and to the depth shown on the block-plan and section, Plate III., with a fall of not less than 6 inches to every 100 feet, and to fix and make perfect and secure, No. 8 15-inch earthenware gully-traps, and No. 4 syphons of the best and most approved description. To lay a 6-inch similar

connecting pipe from principal and servants' water-closets, as well as 4-inch glazed pipes, from sink in back kitchens and front areas into the above-named or principal drain, with all necessary bends, traps, &c., to render the drainage perfect. Build in 9-inch sound stock brickwork, the rain-water tank, and complete the same in the manner shown and described, and to the dimensions exemplified on Plate XIV., viz.: The walls all round to be built in 9-inch brickwork in cement, and the bottom to be paved with two courses of bricks laid flat in the same material, upon which are to be two courses of tiles bedded in cement, and the whole to be rendered all round with compo $1\frac{1}{4}$ inch thick, and all the external portion to be well puddled. To lay and fix complete 4-inch glazed earthenware socket-pipes, from the rain-water pipes of roofs into the said tank, and a 6-inch pipe taken from ditto near the top as overflow pipe, with all necessary bends, neck, or traps, that may be requisite for the full completion of the conveyance of the water to and from the tank and the drainage.

Building.

The whole of the brickwork to be executed with sound hard-burnt stock bricks laid in well-made mortar, composed of Dorking lime (or any other that approximates to the same quality), mixed in the proportion of one measure of lime to three of clean sharp river or road sand, free from loam or earthy particles.

The whole of the external walls of the erection as high as the ground-floor line to be laid in old English bond, and from thence to the top of the building, to be

carried up in Flemish bond. The front and flank walls are faced with approved red bricks, and the backs with picked stocks, all finished with a neat struck joint. No four courses in either bond to rise more than 12 inches in height, and all the several walls, chimney-breasts, piers, &c., to be built and finished in the manner and according to the dimensions shown and described upon the accompanying plates.

All openings at back to have axed segmental arches turned over them, and all others, to front elevation, to have 14-inch arches of the best picked malms rubbed and set in putty.

The foundations to be laid in three courses, and the piers for sleepers to be built 9 inches square, as shown and described on Plate XV. To provide and lay a course of slates between two beds of cement on all the walls at the level of the ground surface of the principal building to prevent the rising of the damp.

Each storey of the building to have two double tiers of hoop-iron bonds, of No. 12 gauge, properly tarred and bedded round and across all the walls of the building. To build up the bay-windows and porches to entrance-hall in cement, and according with the manner and dimensions shown and described on Plates XXII. and XXIII.

No. 6 air bricks to be inserted between the floor joists of each storey in front, and the same number in the back elevations, for allowing ventilation to the floors.

To turn over all door and window openings $4\frac{1}{2}$ discharging arches closely set, and to each fireplace a $4\frac{1}{2}$ inch brick trimmer, and insert a wrought-iron chimney-bar 2 inches wide by $\frac{3}{8}$ of an inch thick, as shown on

Plate XVII., to all the chimney openings; the bars to have 4½ inch bearing, and to be turned up and down at the ends.

To carry up all the flues as shown on section, and in the direction thereon described, and to properly core and parget the same

To thoroughly bed in mortar all the sleepers, wall-plates, wood bricks, bond-timber, lintels, and all others requiring to be set or bedded in mortar, and to fix in and point with lime and hair all the door and window frames.

A chase in the brickwork of each house to be left where directed, from the ground to the principal water-closet, for soil and water-pipes.

Kitchen Offices.

The walls of these buildings to have two courses of footings, and carried up to their various heights one brick or 9 inches thick, and the flues to be taken as shown on the section, one tier of iron hoop bond, similar to that described for the principal building, to be inserted all round the party and external walls.

A 6-inch glaze earthenware soil pipe to be laid from servants' water-closet into principal or main drain, and a 4-inch ditto from sink in back-kitchen into waste-drain, properly trapped and in connection with waste or soil-pipe of the above-named closet.

To carry up 4½-inch division or protection walls between water-closet, coal-cellar, and back-kitchen. Also to 9-inch spandril brickwork, with necessary footings for the support of steps from ground-floor to garden.

CARPENTER.

All the timber used to be the best Dantzic, Riga, or Memel fir, as free from knots, shakes, and sap as possible, to be cut die square, and all the scantlings figured on the drawings or herein expressed to finish to their full dimensions. No ceiling joists, quarters, or rafters are to be more than 12 inches apart.

To provide and fix all wood bricks where and when required, as well as all necessary centres, screeds, turning pieces, and all other articles necessary for the due execution of the carpenter's work.

Basement Storey.

The sleepers to be of fir $4\frac{1}{2} \times 3$ inches, halved and spiked together, and bedded level and soundly on the brick piers, as shown and described on Plate XV.

The floor joists to be 4×2 inches, framed and well nailed to sleepers.

Wood bricks to be inserted where requisite in jambs of doors, windows, &c., as well as round the walls for fixing the skirting and other joiner's work to.

Lintels to be inserted over all the door and window-openings, 3 inches thick, and the width of the jamb; and to have at least a 9-inch bearing on each jamb.

Ground Floor.

Wall-plates $4\frac{1}{2} \times 3$ inches to be inserted the whole length of front and back walls, to be halved and dove-tailed at the angles of the two external flank walls, and return upon the same not less than 6 feet, to form a connecting bond with the front and back walls of the building. A wall-plate of the same scantling to be also

inserted upon the top of the wall dividing breakfast room from kitchens.

The floor-joists to be 9 × 2 inches, and to extend from front to back wall of building and over bay window, and to be bolted and spiked to the wall-plates. The joists to be herring-bone trussed, and to have on the floors of each house No. 3 1-inch wrought iron tension-rods inserted, as shown and described, with the trimmers on Plate XIX. It must be distinctly understood that before the herring-bone trussing and iron tension-rods are applied, the joists on each floor must be shored up in the centre to form a camber of at least 2½ inches, when, after the trussing is filled in, and the above-mentioned rods screwed up, the shoring may be taken away.

The wood trimmers before and on the sides of chimney-breasts to be framed and supported as shown and described on Plate XVI. It may, perhaps, be as well to state, that they are framed at one end into the front one, and rest upon a stone corbel inserted purposely for their support at the other; and after being properly applied to their places, are secured by an iron bar being well spiked to the end of each end trimmer.

The trimmers for well-hole of stairs to be of 1 in. thicker scantling, and supported from the flank walls in a similar manner.

Lintels, bond, wood bricks, and every other requisite to be inserted as before described for the basement floor.

First or Chamber Floor.

The wall-plates to be 4½ × 3 inches, and to extend the whole length of front and back walls of building,

to be halved and dovetailed and well spiked at the angles, and to return upon the flank walls, not less than 6 feet, to form a connecting bond at the angles. The floor joists to be 9 × 2 inches, and to extend from front to back and over bay windows, and to be notched and spiked to wall-plates.

The joists to be herring-bone trussed, and wound up with wrought iron tension rods, as shown and described for the ground floor below.

Also, the trimmers to be framed, fixed, and supported in a similar manner; at the same time providing and fixing all necessary centres, bond, wood bricks, and every other requisite.

Attic.

The wall-plates of this floor to be of the same scantling, and to be fixed on the walls in a similar manner to that above described for the two floors below. The floor joists to be also 9 × 2 inches, and fixed, herring-bone trussed with the iron rods applied in a like manner to those before described, as also the trimmers; with all the necessary auxiliaries alluded to for the before-named floors.

Quarter-partitions.

The partitions to be framed and fixed in the manner shown and described on the Plates XXIII. and XXIV., and the floor joists notched and secured to the heads or sills thereof (*as the case may be*), which heads and sills are to rest on a stone corbel inserted in the party wall for that purpose, and connected together by iron straps, as shown and described as Fig. 2, Plate XXIV. The scantlings to be of the following dimensions, viz.:—

heads and sills, 7 × 3 inches; side and door posts, 4 × 3½ inches; braces, 3½ × 3½ inches; filling in quarters, 3½ × 2 inches; with all necessary bolts, ties, straps, &c., fixed complete.

Cisterns.

A cistern to be framed and fixed in the roof over water-closet, and put together with white lead, as shown and described in Plate XXIII., Figs. 4 and 5, and to be of the following dimensions, viz.:—8 feet long, 6 feet wide, and 3 feet deep; the quarterings of the *heads, sills, sides,* and *bottom,* to be 3 × 3 inches, framed and put together in the usual manner, with 1½ by ¼ thick iron ties at all the angles, properly spiked thereto; the whole to be lined with 1½-inch ploughed and tongued yellow deal boarding.

A smaller cistern also to be prepared and fixed immediately under the one above described, but just above the water-closet, upon the quarter space of stairs between the ground and chamber floors, the size of which is to be 2 feet 6 inches long, 1 foot 6 inches wide, and 1 foot 6 inches deep—to be prepared from 1½-inch yellow deal, ploughed, tongued, dovetailed, and strapped in the usual manner

Roof to principal Building.

The roof to be framed and fixed with wall-plates, tie-beams, queen and king posts, principal rafters, half principal ditto, pole plates, purlins, common rafters, diagonal ties, slips, ridges, &c., as shown and described on Plates XX. and XXI., and with the accompanying explanation, viz.:—Two whole pair of principal rafters to be framed and fixed at the intersection of the hips,

and eight half principal rafters in the position shown on plan of roof to be framed into them; the wall-plates to be properly scarfed and wedged together with oak or iron wedges, and to be halved, dove-tailed, and well spiked at the angles, so as to form and be a continuous bond all round the external walls of the building; the tie-beam and angular ties to be properly cogged down upon the wall-plate; the principal rafters and half principal rafters to be framed with the necessary draft, and in the usual manner, with all the requisite *iron bolts, clips, straps, wedges,* &c., fixed thereon; the pole plates to be scarfed and wedged together, and tenoned and fixed at the angles, so that it may make a continuous tie to the roof, in the same manner the wall-plate does to the walls, and the purlins to be scarfed where required, and fixed to hips in the usual way—and to be bridged down upon principal rafters; the hip rafter to be framed into the dragging tie, and the common rafters to be notched on to purlins and pole plate. The ridge board and hip rafters to rise full 2 inches above the top or line of common rafters for dressing the lead round. The scantlings of the timbers for this roof are to be as follows:—

The plate for fixing brackets to	$4\frac{1}{2}$ by $3\frac{1}{4}$
Wall-plate	$4\frac{1}{2}$ „ $4\frac{1}{2}$
Cantilevers, to be halved and nailed to feet of common rafters	4 „ 2
Tie beam	9 „ 4
Principal rafters	7 „ 4
Pole plate and purlins	7 „ 4
Common rafters	4 „ 2
Queen and king posts in clear of joggles	4 „ 4
Braces or struts	4 „ 3
Hips and ridges	12 „ 2
Diagonal and dragging ties	$4\frac{1}{2}$ „ $4\frac{1}{2}$

Battens for slates	2 by $0\frac{3}{4}$
Collar pieces	7 „ 3
To prepare and fix to collar pieces of roof ceiling joists	$4\frac{1}{2}$ „ 2

And to fix, as shown in Plate XX., all canting fillets, facia, as may be required, to their various sizes, &c.

Kitchen Offices.

To prepare and fix in jambs and other places required, and, where directed, wood bricks for fixing and completing the joiner's work, and to prepare and bed lintels over all door and window openings; the width of the jambs $3\frac{1}{2}$ inches thick, and to lay 9 inches on each jamb.

The servants' privy to have a wall-plate $4\frac{1}{2} \times 3$ inches inserted, and to have floor $4\frac{1}{2} \times 2$ inches notched thereon, and trimmed for pan of closet.

The roofs over these buildings to be plain lean-to roofs, each declining from the party-wall, and to the same inclination as that of the principal building, and to comprise a *wall-plate, tie-beam, principal rafter, forming common rafter as well,* a *purlin* supported by a *strut* from the *tie-beam,* and a *pole plate;* the whole to be battened for receiving slates, &c.

The scantlings for these offices are to be of the following dimensions, namely:—

Wall-plates, $4\frac{1}{2} \times 3$ inches; tie-beams 8×4 inches; pole plate, $4\frac{1}{2} \times 3$ inches; principal rafter, 8×3 inches; common rafters, $3\frac{1}{2} \times 2$ inches; ridge-board, $6 \times 1\frac{1}{2}$ inches; and battens for slates, $2 \times \frac{3}{4}$ inches.

Two cisterns to be prepared and fixed in roofs over the sinks for receiving the water from the service and the rain-water tank; these cisterns are to be 4 feet long, 3 feet wide, and 2 feet 6 inches deep, and framed

with skeleton angular framing; that is, to have a head and sill all round with quartering, at all the angles similar to that described for the cistern in principal roof, with one upright in the middle, and a corresponding piece across the bottom, the whole to be lined with 1½-inch yellow deal, ploughed, tongued, and put together with white lead. A partition in each cistern, prepared in the same manner, from 1-inch yellow deal, to be inserted and grooved into sides and bottom.

To provide and fix, when and where directed, all centres, bond, timber, wood bricks, springing pieces, &c., and set out all necessary work, and to do or cause to be done all and everything that is required of a carpenter in a building, providing all materials, the best of their respective qualities, and all requisite plant for the full completion of the work.

SMITH AND IRON-FOUNDER.

All the iron work, except that particularly described to be *cast*, to be of the best malleable metal, as free from blister or any other imperfections as possible. To prepare, deliver, and assist in fixing No. 16 wrought-iron chimney bars, of the dimensions of the opening shown on the various drawings, and of the form and manner described in the detailed Plates, each bar to be 2 inches wide, and ⅜th of an inch thick, to have a 4½ bearing on each joint, and to turn up and down 2½ inches at each end.

To prepare and deliver No. 8 iron straps, 2 feet 6 long, 2½ inches wide, and ¼-inch thick, punched with holes for the necessary spikes, &c., for tieing heads and sills of partitions together, and as shown on Plate XXIII., Fig. 2, prepare No. 6 iron clips for partition

posts, 2 feet long, 3½ clip, 2 inches wide, and ¼ inch thick.

To prepare, provide, and assist in fixing, No. 18 one-inch wrought iron tension rods, to extend from front to back walls of the building, three of which are to be fixed in each floor of each house of the building, with ⅔-inch head, one inch thick at one end, and taped up at the other end at least four inches, with a nut of the same size as the head, with a pair of washers to each rod, 6 inches by 3 and ¼ of an inch thick. See Plate XIX.

To prepare and deliver No. 12 iron clips for feet of principal rafter, as shown on Plate XXI., Fig. 1, 18 inches long, 4 inches clip, 2 inches wide, and ¼ inch thick, pierced for the necessary spikes, &c.; No. 4 clips for foot of queen posts, Figs. 3 and 4, 2 feet long, 4-inch clip, 2 inches wide, &c., ¼ inch thick, with mortice for wedges, 1½ inches deep, and ⅜ thick, and a pair of corresponding wedges to each clip.

No. 4 pairs of iron straps to fix on the heads of queen posts, *stretching piece* and head of principal rafter, made to the form shown on the same plate, 2 feet 6 inches long, 2 inches wide, ¼ inch thick, pierced for the requisite spike, &c.

No. 4 ¾-inch bolts for king posts, 2 feet long, taped down 3¼ inches, with 2 heads and washers, 4 inches by 3, and ¼ of an inch thick.

No. 8 clip similar to those described for the whole principal rafters, to be provided for the half principal rafter. No. 8 clips also to be provided for the heads of the same, 1 foot 6 inches long; clip 4 inches by 2 inches wide, and ½ inch thick, with all necessary spikes, nails, wedges, &c., for making the work complete.

To provide and fix No. 8 angular irons to top and sill of cistern in roof, 1 foot 6 inches upon each return, 2 inches wide, and $\frac{1}{4}$ inch thick; and also No. 8 for the two smaller cisterns, 1 foot long, $1\frac{1}{2}$ inch wide, and $\frac{3}{16}$ inch thick.

STONEMASON.

To put to all the external doorways Yorkshire stone solid tooled steps, with mortice holes for receiving the ends of door-posts.

To provide and fix No. 8 approved stoneware trapped gullies with iron grids when and where directed; as also a 5-inch York landing, 10 feet long by 7 feet wide, or two stones to correspond to the same dimensions over the rain-water tank, with every preparation for receiving the slate filter, as shown on Plate XIV.

To prepare and bed No. 20 Yorkshire stones, 1 foot 3 inches square, and 1 foot 4 inches deep, for receiving trimmers to floors and heads and sills of partitions tooled as shown on Plate XXIII.

To prepare and fix 100 feet run of York throated coping, 12 × 3, to area of front and back elevations, and to kitchen offices; properly bed same in cement with all necessary angles and returned ends.

To prepare, provide, and fix tooled, rubbed, and throated window sills, 8 inches wide and $3\frac{1}{2}$ inches thick, properly dished, to all openings of windows in front and back elevations and kitchen offices, according to the dimensions shown on the various drawings.

To prepare and fix to the porches of entrance doors a 6-inch tooled and rubbed landing, with steps leading thereto, 12 inches by 6 inches, bedded to brick span-

drils, as shown on Plate XXII. Also, to fix a tooled landing 7 inches thick to the back or garden entrance, and the steps from thence to the garden, which are to be $2\frac{1}{2}$ inch tooled treads and risers securely bedded on brick spandrils carried up for that purpose.

To provide and fix in back kitchen a stone sink, to size shown on plan and 6 inches deep, with a hole cut and dished to receive bell trap and waste water pipe.

To cut in the stonework all necessary holes, mortices, rebates, grooves, as required, and all other work pertaining to the trade of a mason.

PLUMBER.

All the hips and ridges of principal roof to be covered with 6 lb. milled lead, and to be laid down over the slate at least 6 inches on each side with the usual lap, and secured in the most approved manner. The dormer lights to attics to be also covered with 6 lb. lead, and the vertical sides of each with 5 lb. lead. All the flashings for this roof, as well as that over kitchen office, to be of 5 lb. lead, and to dress over the slates and up the side at least 6 inches, and where requisite to be let into the brickwork at least 1 inch, with all necessary solder, holdfast screws, nails, &c., with every other requisite for making the internal roofs impervious to wet, from rain, snow, or other causes.

SLATER.

The roof over principal building to be covered with best Bangor Countess slating, with at least 3 inches lap, and the usual gauge securely fixed to the battens, with 2 copper nails to each slate; and to cover the

kitchen office with lady slates, with the usual lap and gauge fixed to the battens, with 2 zinc nails to each slate, with all the necessary dressings to hips, valleys, and eaves, &c., and both roofs to be securely pointed with lime and hair.

To provide, prepare, and fix No. 12 3-inch slate cantilevers, to the size and form shown in the drawing of details for roof.

To provide and fix in the rain-water tank a $\frac{3}{4}$-inch slate filter, according with and to the dimensions described on the plan and section Plate XIV., with all necessary lifts, perforated plates, taps, &c., and apparatus complete.

ZINC WORKER.

To prepare and fix all round principal building a gutter of the best Belgian zinc of No. 15 gauge, to the form and dimensions shown and explained on Plate XXI., with all proper falls to the various dimensions, and so manufactured in external appearance as to be level with the soffit of the projecting eave of the building, as shown on the before-named plate.

To put up and securely fix No. 6 down pipes of 4-inch diameter in the position marked on plan of roof.

To provide and fix the said in the position marked on the plan of roof, and each to have a suitable cistern head, with all necessary shoes, laps, joints, holdfasts, and every requisite to connect them with the earthenware pipes laid for conveying the water into the rain-water tank.

The gutters and down pipes from the roof over kitchen offices of 3-inch diameter, with corresponding cistern-head.

Also to provide and fix a 2-inch downcomer, with every requisite bend from the flats of the bay windows and entrance porches to the drain in front area.

FINISHINGS.

JOINER'S WORK.

Attic Floor.

The dormer light in each room to be fitted up with two-inch beaded, and rebated frames, and $1\frac{1}{2}$-inch ovolo moulded casements, hung on $2\frac{1}{2}$-inch butts with all requisite quadrant stays, fastenings, &c., for the opening and closing of the same, in an impervious and efficient manner.

Floor.

The floor to be $1\frac{1}{4}$-inch white deal, and laid folding; skirting ground 2 inches wide by $\frac{3}{4}$ thick, chamfered to receive plaster, and as shown on Plate XXVI., Fig. 2, to be fixed all round the rooms, and a similar description of ground to door and window jambs, which are to be covered with a $2\frac{1}{2}$-inch moulding, to form an architrave and break the joints of plaster, and grounds, and to the ground round rooms, is to be fixed a 6-inch square skirting-board. The jambs of doors to have a $\frac{3}{4}$-inch beaded lining, and to have a slip braded on to form the rebate for doors, which are to be $1\frac{1}{2}$-inch; four panel square, hung with suitable butt hinges and fastenings.

Chamber Floor.

The floor to be $1\frac{1}{4}$-inch yellow deal, with a straight joint, and splayed heading joints, with mitred borders

to hearths, a ground 2 inches wide by 1 inch thick, chamfered, to be fixed all round the rooms for receiving the plaster and fixing the skirting to, and also one 3½ wide of the same thickness round all door and window openings. The housemaid's small closet on this floor to be formed with a 1½-inch square panelled partition, and the door to correspond with the other described for this floor.

The sashes and frames for the back rooms on this floor, to be double hung. The frames to be deal cased, with oak sunk sills, brass cased pullies, with 1½-inch ovolo sashes hung with cast-metal weights, patent cord, &c., and the windows to front rooms to have 2-inch ovolo casements hung to solid frames and oak sills. The finishing to all these windows to be as shown and described on Plate XXVI.

The jamb lining for doors to be 1½-inch thick, beaded and single rebated, and to have 2-inch four-panel moulded doors, properly hung with 3½ butt hinges.

The skirting to be moulded 9 inches wide, and fixed in the manner shown at Fig. 2, Plate XXV.

Ground or Principal Floor.

The floor to be 1¼-inch yellow deal, straight jointed, splayed heading, joints edge-nailed, and mitre borders to hearths.

Grounds.

Skirting grounds 2½-inches wide, by 1 inch thick, to be fixed all round the floors for receiving the plaster, and fixing the skirting to the upper edge, to be ploughed,

and all angles to be dove-tailed together, as well as the ends secured in a similar manner to the vertical grounds of doors and windows—(see grounds to venetian window) Plate XXV.

Entrance Hall.

The door frames to be 4 inches by $3\frac{1}{2}$ inches, rebated and beaded, with double rebated transom head, and to be tenoned into stone step.

The doors to be $2\frac{1}{2}$-inch, two panel bolection moulded on both sides, $\frac{7}{8}$th panels, and to be hung with 3 pair of $2\frac{1}{2}$ butt hinges.

The fan-light to be a 2-inch lamb's tongue moulded light and fixed above door, with grounds, linings, and architraves, corresponding with those shown and described for the floor on Plates XXV. and XXVI. To put up, with all the corresponding fittings, a pair of 2-inch sash doors, with a suitable light above, to divide the entrance hall from passage and stairs.

Also to provide and fix a 2-inch sash door and partition to form the lobby under water-closet, and divide the stairs from the garden or back entrance to this floor, with all suitable finishings, and according to the one above described for dividing the hall from the stairs. The door frame from lobby to garden to be prepared for fan and side lights (*as shown on elevation of back front*), the external posts and head to be $3\frac{1}{2}$ inches by 3 inches, and the two vertical posts, as well as transom head, to be $3\frac{1}{2}$ inches by $2\frac{1}{2}$ inches, to be beaded, rebated, and tenoned into step, in a similar manner to that described for the front entrance door, and to have a 2-inch sash-door fan and side-lights, with $1\frac{1}{4}$-inch framed boxing shutters as high as the transom

head, the grounds, linings, and other finishings, to be similar to those shown on Plate XXV., and described for the venetian window in the back parlour.

Bay-windows, Front Parlours.

These windows to be fitted up and finished in the manner shown and described on Plate XXVI., with deal cased frames, oak sunk sills, and the centre portion to have brass cased pullies, patent cords, and cast metal weights, and prepared to receive the sashes, which are to be 2-inch lamb-tongue moulding, the middle sashes double hung, and those of the sides fixed. The other portions are to be prepared and fixed in the manner shown on the before-named Plate XXVI., and finished with the grounds, linings, soffit, skirting, architraves, as there shown and described.

Back Parlour.

The venetian window in this room to be fitted up in the manner shown and described in Plate XXV., Fig. 4; the middle sashes to be double hung, and the side lights fixed. To have $1\frac{1}{4}$-inch moulded shutters hung with brass, cased pullies, patent cord, and cast metal weights; and to have $1\frac{1}{4}$-inch framed and moulded back. The grounds, linings, architrave, &c., in a corresponding manner to those described and shown for the front parlour or dining room.

Doors.

To prepare and fix $1\frac{1}{4}$-inch double rebated and beaded jamb-lining to the grounds for the folding-doors between the two parlours. The doors to be $1\frac{1}{2}$-inch

double moulded, two panels in each door, and the grounds, architraves, &c., to be of the same description, and to correspond with those before described. The jamb-linings for the other doors to be of the same description as before stated, and to have 1¼-inch 4-panel doors moulded on both sides, with corresponding grounds and architraves.

Skirting.

All the skirting for this floor to be board wide and 1 inch thick, and to be surmounted with a 1½-inch rebated moulding.

Basement.

Breakfast Room.—The floor to be 1¼-inch yellow deal, straight joints and splayed headings, and mitred borders to hearth. The bay window to have sashes and frames similar to those described for dining-room above, and to have sliding shutters similar to those shown and explained for the back parlour windows, with door skirting, lining, and all others of a corresponding character.

Kitchen.

The floor to be 1¼-inch deal, folded and mitred border to hearth.

Sash Frames.

The sash frames to be of a similar description to those already described for the upper floor, and to have 1½-inch ovolo sashes, and 1¼-inch square framed sliding or hung shutters with 1-inch grounds and 1½ moulding to break the joint and form architrave, as those described for the attic storey.

Cellar Door

Under principal entrance and back entrance doors to have frame 3½ by 3 inches, beaded and single rebated and tenoned into stone steps or sills, and to have a 1½-inch 4-panel bead and butt door. The back entrance door frame to be of similar scantling, but framed with a transom head for a 1 fan light, and the door to this frame to be a 1½-inch sash door with a lifting shutter; and all other doors on this floor to be 1¼-inch 4-panel square doors, with lining and finishing as above stated for the attics.

Stairs.

The stairs from basement to ground floor to have 1¼-wrought yellow deal strings, with 1¼-inch treads and 1-inch risers blocked and bracketed, and securely housed into the strings in the usual manner.

The partitions forming the spandril framing, as well as those forming pantries and store closets, to be 1¼-inch square panel, and to have a 6-inch ¾ skirting board, to correspond with others that are to run round the passage.

Stairs from ground floor to chamber storey to be geometrical, with one circular string and quarter circular on landing, as shown on Plan, and to have 1¼-inch yellow deal treads, risers, carriage and string boards, with all requisite carriage furrings to soffit, &c. The treads to have round and hollow nosings. The risers to mitre into the external string, which is to be dovetailed to receive the balusters and the return nosing; the other end of both treads and risers to be housed and securely wedged into the external string; a full scroll curtail step, with veneered riser and circular part

to frame into external string, to be firmly fixed at the starting of the flight, and the succeeding step to be gradually carved until they join the straight flyers. (See Ground Plan, Plate V.) The whole flight to have $\frac{3}{4} \times \frac{5}{8}$ inch-square balusters dove-tailed into the end of tread and string, and covered with the mitred nosing. One ornamental iron baluster, taped, and to have nuts and screws complete, to be securely fixed in centre of scroll of curtail step, and No. 3 plain iron balusters, corresponding with those of deal before described, to be fixed where requisite on the flight. The whole to be surmounted with a $2\frac{1}{2}$-inch moulded Spanish mahogany hand-rail, sunk to receive the balusters and properly wreathed to well, and to have a corresponding mitred cap over curtail step. The same description of skirting as described for rooms of ground floor to be fixed all round hall and passage, and the same mouldings to continue up inside string of stairs: finding and applying all necessary joints, screws, and every other requisite to make the work complete.

Water Closet.

On quarter space.—The partition dividing stairs from water-closet to be a 2-inch framed and moulded sash partition with sash doors to correspond, prepared for receiving ground or stained glass, with the moulded skirting of stairs continued round on the stair side and the whole to finish in accordance with the stairs.

Inside.—The window-frame and sash to correspond with the one described for the chamber storey. To fit up the seat and riser with $1\frac{1}{4}$-inch Honduras mahogany, the seat to be properly dished out to the form of pan, and to have a beaded box for handle. This seat to be

covered with a framed and beaded skeleton for the flap to hang to, which is to be $1\frac{1}{4}$-inch selected mahogany, hung with brass butts, and both frame and flap to have a projecting moulded nosing; $\frac{1}{2}$-inch beaded skirting 6 inches deep to be fixed round back and sides, as also on ground in front of riser. The whole to be fitted up with all necessary scantling, bearers, &c., for the support of pan and apparatus, as well as the efficient support of the seat and riser, in the most approved manner.

Also to fit up with 1-inch Honduras mahogany an angular lavatory and closet, the closet underneath with a 1-inch square panel-door, hung to a beaded and suitable skeleton frame, with all suitable appendages for receiving basins and depositing towels, &c., and also to fix over chase of soil, waste, and supply-pipe, a 1-inch mahogany-framed skeleton-ground, rebated and beaded for a corresponding board, to be slightly screwed to the same for allowing easy access to the before-named pipe; a small moulding, to be fixed over ground, and plaster to break the joint; and to fix on all other articles that may be required for the full completion of the closet.

Kitchen Offices.

All the external door-frames to be $4\frac{1}{2} \times 3$ in. yellow deal, beaded and rebated, and tenoned into stone sills or steps. Those to servants' water-closets, and to the lobby between kitchen and back-kitchen to be framed with transom heads, and to have $1\frac{1}{4}$ lights fixed therein. The whole of the external doors to be 2 inch bead and butt, 4-panel doors framed flush on one side, and square panels on the other. All internal doors to be

fitted up in the same manner as those described for the attic. The doors for coal-shoots to have a small $2\frac{1}{2}$-inch × 2-inch frame rebated and beaded and 1-inch ledged doors.

The sash-frames and sashes for kitchens to be of a similar description to those described for chamber-floors; and each window to have a pair of $1\frac{1}{4}$-bead, bead and flush-panel shutters hung to the frame on the outside.

The small window to pantries, marked D D on the basement plan, to have $2\frac{1}{2}$ × 2-inch beaded and rebated frames, and a $1\frac{1}{2}$-inch sash hung upon centres for ventilation. The servants' water-closets, marked A on the same plan, are to have floor-joists 5 × 2 inches, and laid with $1\frac{1}{4}$ yellow deal. The seat and risers to be also of $1\frac{1}{4}$-inch deal, properly fixed and blocked to pan, and dished out in a corresponding manner; and a beaded box prepared for the pull; a movable $\frac{3}{4}$ beaded casing to be placed over pipes, with every article to make the work complete.

PLASTERER.

Attic.

Lath, plaster, and set the ceilings and partitions, and also render, and set the walls of the same.

Chamber Floor.

To lath, plaster, float, and set the ceilings and partitions, and render, float, and set the walls; run a plain moulded cornice round the front room of this floor of 12 inches girth, and one round back room of 10 inches girth.

Ground Floor.

Entrance and passage—lath, plaster, float, and set the ceilings; partitions to be lathed, floated, and set in stucco; and render, float, and set the walls in stucco; and finish the whole for painting; and a plain moulded cornice of 10 inches girth to be run all round so far as the break of stair will admit.

The front and back parlours to have their ceilings and partitions lathed, plastered, floated, and set, and to have an 18-inch plain moulded cornice run round both rooms.

Basement Floor.

The ceilings of this floor to be lathed, plastered, floated and set; and the walls rendered, floated, and set; the front room, or breakfast parlour, to have a plain moulded cornice of 10 inches girth run all round.

Stairs.

The stairs from basement to ground floor and all other contiguous conveniences, not before alluded to, to be finished as the rooms of the attic floor: the next flight from ground floors to chamber floors, with the lobby and water-closet included: to finish in the manner described for the entrance halls, that is to say, the soffit of the stairs and ceilings to be lathed, plastered, and set, and partitions to be lathed, plastered, floated, and set with stucco; and all the walls rendered, floated, and set in stucco, and finished for painting. The stairs from chamber floors to attic to be finished in a corresponding manner to that already described for the chamber floor. All the ceiling and soffits to be twice lime-whitened.

Kitchen Offices.

To lath, plaster, and set all the ceilings, and to render and set the walls.

The ceilings and walls of these buildings to be twice lime whitened.

Outside Work.

The tops of chimneys to be flaunched in cement all round, with weathering and throating, as shown on front elevation, Plate IX.

The soffit of the eaves of principal building to be bracketed out on framed bearers to form a cove, as shown on section, Fig. 1, Plate XXI., and to be lathed, plastered, and set in cement, and twice coloured with Portland cement wash, the portion round back to be finished with a plain soffit, and the cove to be properly returned in itself.

MASON.

Attics.

To put to each fire-place in attic a hearth and back hearth of 2 inches Yorkshire stone, and to each opening jambs and head 5 inches wide and 1 inch thick, with a shelf of the same dimensions, properly cramped and fixed together.

Chamber Floor.

To provide and fix on this floor No. 4 marble chimney piece, with back hearths, slabs, and shelves complete, to the value of 70*s.* each.

Ground Floor.

Provide and fix on this floor No. 4 marble chimney

pieces, with back hearth, slabs, and mantel complete, to the value of £5 each.

Basement Storey.

To provide and fix in the breakfast-room No. 1 marble chimney piece, with back hearth, slab, and mantel complete, to the value of £3 10*s.*

Kitchens.

To fix complete, rubbed York chimneys, with mantels and hearths complete, to the value of £3 each, and to the back kitchen chimney pieces of the same description of stone to the value of 30*s.* each.

To pave the lobby leading from kitchen to back kitchen, and the whole of the kitchen offices, as well as the front and back areas, with 2½ tooled York paving.

FURNISHING IRONMONGER.

NOTE.—In no other trade does the quality of the goods vary so much as that of the ironmonger. It is therefore thought desirable to state that the various articles here specified are intended to be of a thoroughly good and substantial character.

Attic Floor.

To provide and deliver for dormer lights on this floor two pairs of 2½ butt hinges with strong brass quadrant stays, for opening and closing the lights, as also No. 4 barrel 4-in. bolts, and requisite staples for fastening the same, with all necessary screws, nails, &c. Also to

deliver No. 4 6-inch iron-rim locks, with box staples, keys, and brass furniture, with all necessary screws and nails complete for the doors to these rooms.

Chamber Floor.

To provide and deliver all the brass cased pulleys, patent cord, cast metal weights, &c., shown on the drawings, and described in the joiner's work for this floor, as well as 2-inch spring fastenings to each sash.

To provide No. 16 pair of butt-hinges, with all necessary screws, &c., as well as No. 4 6-inch morticed locks, with brass furniture complete, for the principal doors; No. 2 4-inch brass spring and bolt latches for dressing rooms, and No. 2 4-inch iron closet locks, with all requisite striking plates and furniture complete.

Water-Closet.

To provide the brass cased pulleys, cords, weights, fastenings, &c., for this window, as before described, as well as one pair of $2\frac{1}{2}$ butt-hinges for door, and a $4\frac{1}{2}$ brass spring and bolt latch with furniture complete for door.

Ground Floor.

To provide and fix to the windows of the various rooms on this floor best patent flax lines, cast-iron weights, Hopkinson's or other approved patent brass sash fastenings, also brass flush lifts and handles for opening and closing windows, as also a set of a similar description for shutters of back-parlour.

To provide for entrance doors to hall No. 4 pair of

4-inch butt-hinges, with all necessary screws, &c., and a best 10-inch draw-back mounted lock, with staple and all necessary furniture complete; as also a 12-inch door-chain, with brass knobs and asp complete, and two 10-inch barrel bolts, with staples and plates complete for top and bottom of door. The back entrance doors to have hinges, locks, bolts, and chain of a similar description; the shutters to have 18-inch bow-latch shutter-bars complete, with every necessary, &c., and to provide for doors dividing lobby from stairs, a 3-inch brass spring bolt latch.

To provide for shutters in back parlour No. 4 1-inch brass flush rings, with No. 2 brass clips for fastenings. To provide for doors not before alluded to on this floor No. 8 pair of 3-inch butt-hinges, with all necessary screws, &c., and for folding doors No. 4 12-inch brass flush-bolts, with all necessaries, &c., as also to provide No. 6 inch mortice locks, with brass striking plates and furniture complete.

Breakfast Room.

To provide for the sashes brass cased pulleys, patent cords, and fastenings, as described above for back-parlour; but the shutter will require three pair of brass cased pulleys with weights, fastenings, and cords, complete; the door of this room to be provided with a 6-inch mortice lock, and brass furniture complete.

To provide for kitchen window and shutters the same number of brass cased pulleys, cords, and fastenings, as before described for the back-parlour.

To provide for the six back-entrance doors 9-inch iron spring-stock locks with staples complete, No. 6 10-inch door chains, and No. 12 10-inch barrel-bolts

and staples all complete, as also No. 6 6-inch iron rim stock locks with box staples complete for the other doors, and to provide No. 24 pair of 3-inch butt-hinges, as well as No. 8 pair of 2½ ditto, with all necessary auxiliaries, &c.

To provide one ornamental cast-iron baluster, 1¼ diameter, 3 feet 6 inches long, tapped at one end, with nut and plates complete for curtail step, and three other, ¾ by ⅝, two feet 5 inches long.

It is to be distinctly understood that the furnishing ironmonger is to deliver all articles here expressed, and all others that may be requisite for the due execution of the work into the possession of the joiner, who will apply and fix the same in their relative positions, providing and delivering, as may be required, glue, brads, nails, screws, and materials generally supplied by the ironmonger.

BELL-HANGER.

To provide and hang bells with all proper springs, cranks, wires, &c., of the size required, and in the position when and where may be hereafter directed, to the value of £10.

PLUMBER.

To line the cisterns in roof of principal building, as well as the four smaller ones described for supply of water-closet and kitchen offices, with six pounds milled lead, in the most efficient and workman-like manner, and to lay on from principal main to the large cistern in each house a 1-inch lead main supply-pipe, with a 6-inch ball-cock properly applied at the cistern end, with a 1¼-in. lead "warning pipe" to be taken from cistern

to discharge in the open air. The house-service, to be 1-inch calibre, to be taken into small cisterns over water-closets, and from thence into cistern in roof of kitchen offices; each of the small cisterns to be furnished with a suitable ball-cock, warning pipe and service with rose-tops, and every other requisite article. The water-closets to be fitted up with approved patent valve closets, fitted up complete, and to have a 4-inch soil-pipe connected and continued perfectly sound into principal drain and carried up above roof as ventilator; and to complete the closet apparatus with all necessary bends, valves, traps, &c., to render them efficient and complete in all their actions, the service pipes to be brought from the small cistern above, as well as two ½-inch service pipes to supply the water to the washing-basins in corner; to provide and fix No. 2 10-inch wash-basins, and fix to the ½ pipes suitable cocks, and to the basins a stop valve, with chain and waste pipe complete, into principal drain.

To provide and fix to each house one of Warner's vibrating lift and force pumps, with all necessary pipe, bosses, and fastenings for supplying the filtered rain water into the cisterns situate in roof over kitchen offices, &c., and bring from the said cisterns two 1-inch service pipes to sinks in washhouse, with all proper taps, &c., as well as the waste pipes from cisterns, and all other articles that are requisite to make the supply of water complete; to provide and fit up in servants' privies two single-valve pan water-closets, with flushing apparatus, and pipes of 1-inch diameter for water brought from cisterns in roofs, with necessary bends, traps, joints, &c., for carrying soil into principal drain.

The plumber to furnish and provide the water-closets as described, with all necessary traps, syphons, bends, pipes, lead, solder, joints, taps, cocks, bosses, roses, and every other article that is necessary for the full completion of his work.

GLAZIER.

To glaze the windows in attics with good seconds Newcastle glass, properly bedded and back puttied, and the window in chamber-floor and water-closet with good crown glass, which is to be well bedded, bradded, and back puttied.

Ground Floor.

All the sashes on this floor to be glazed with 21-ounce crown glass.

Basement Floor.

The bay-window in breakfast room to be glazed with 21-ounce glass, and all the other windows to be with the best Newcastle seconds glass.

PAINTER.

To knot, prime, and paint in three oils all the outside wood and iron work, and to flat any of the inside work when and where directed, and to finish the other in any colour that may be hereafter decided on.

PAPER-HANGER.

To prepare and hang (*except the hall passage, staircase, water-closet, and landing, which are to be painted*) the whole of the chamber floor with paper hereafter to be chosen, to the amount of 1*s.* 6*d.* a piece, and

the front and back parlour on the ground floor, and the breakfast room on the basement floor, with paper to the amount of 2*s.* 6*d.* per piece, hanging and bordering included.

General Conditions.

It is to be distinctly understood that the party or parties contracting for the erection of the buildings herewith described, are to provide and deliver on the premises, all the materials, the best of their respective qualities, also to provide and furnish all necessary plant, scaffolding, labour, and all other articles that are requisite for the full completion and finishing of the work, according with the accompanying drawings and this specification; and if anything should be shown in the drawings and not herein specified, or anything herein specified that is not shown on the drawings, the same to be executed as if fully shown and explained in both; and if any alteration from the drawings or this specification should take place during the progress of the work, such alteration not to make the contract or estimate null and void, but the expense of such deviation to be added to, or deducted from (*as the case may be*), such estimate.

It is requested that the amount for each particular trade, with a tariff of prices upon which such estimate is founded, shall accompany each tender.

Specifications are generally and should be always accompanied by a schedule or statement in an orderly and classified form, of the quantities of every material that will be required in the structure specified in the judgment of the architect. This is called the bill of quantities, of which the following is an example, as applying to the foregoing specification.

A bill of quantities is for the guidance both of the architect and of the artificer, as respects the estimates; but errors or omissions in it are never to exonerate the artificer from the completion of his contract.

BILL OF QUANTITIES.

Quantities of the various Materials, and the Excavation necessary, for the erection of two Houses proposed to be built on a plot of ground situate

according to the various drawings (numbered from 1 to 17 inclusive) and specifications made for that purpose.

PRINCIPAL BUILDING—CARCASS.

EXCAVATOR.

Cube yards.		at £	s.	d.
573	To be excavated and carted away . . .			
	Levelling, filling-in, pugging, ramming, and carting away earth, rubbish, &c. . .			

BRICKLAYER.

Rods.	Super.	Run.		at £	s.	d.
		200	Of 6-inch glazed socket pipes, with requisite bends . .			
		200	Of 4-inch ditto . . .			
			No. 8 15-inch gully traps .			
			No. 4 6-inch syphons .			
28	..	..	Of reduced or standard brickwork			
	64	..	Of rubbed malm arches .			

CARPENTER.

Cube feet.	Super.	Run.		at £	s.	d.
25	..	..	Of Dantzic fir, for sleepers .			
925	..	..	18½ loads of Riga timber, framed in floors, partitions, roof, cisterns, &c., according to drawings and specification*			

* It perhaps is necessary to observe that this calculation embraces the *net* quantity of timber required for the erection of the carcass of the buildings, exclusive of any other article.

SMITH AND IRONFOUNDER.

Weight.		at £	s.	d.
1140	Hoop-iron bond			
160	Chimney bars			
110	Clips and straps for partitions . . .			
1080	For tension rods, &c.			
187	For clips and straps to roof			
26	For bolts, &c.			
56	Ties to cistern, &c.			
2759 lbs. = 24 cwt. 71 lbs. Exclusive of all spikes, holdfasts, nails, screws, and every other article requisite for the sound fixing of the above-named works, which are to be calculated in the estimate.				

PLUMBER.

lbs. weight.		at £	s.	d.
900	Of 6-lb. lead, for flashings, &c. . . .			
1728	Ditto, to dormer lights			
1320	5-lb. ditto, to sides of ditto			
1050	6-lb. flashings to lights and chimney, &c. . .			
145	Ditto to cisterns			
5143 lbs. = 45 cwt. 3 lbs. weight of milled lead, exclusive of any other article.				

MASON.

Cube.	Super.	Run.		at £	s.	d.
50	..	..	Of tooled steps for doors .			
			No. 8 15-inch gulley-stones properly dished, and five holes in each . . .			
	70	..	Of 5-inch York landing for rain-water tank . . .			
100	..	..	Of tooled York, for trimmers, of floors, and heads and sills of partitions, &c. . .			
		50	Of 12-inch × 3-inch throated coping, for area walls, &c. .			
		36	Of stone core for cornice, 1 ft. 4 in. wide, 4 in. thick .			
		60	Of dished amd throated window-sills			
	30	..	Of 6-inch rubbed York landing, for entrance porches . .			
50	..	..	No. 20 tooled and rubbed York steps, for entrance doors .			
	36	..	Of 7-inch tooled landing . .			
		75	Of 2¼-inch tooled treads, 13 in. wide, and			
		71	Ditto, for riser, 7 in. wide, for steps from back entrance of ground-floor to garden . .			

SLATER.

Square.		at £	s.	d.
24¼	Of Duchess slating, with all cuttings and pointings complete			
	No. 12 slate cantilevers or brackets, for principal elevation—(See details of roof, Plate XXI.)			
	No. 1 sawn slate filter, as shown and described on Plate XIV., with all necessary bolts, nuts, screws, rods, perforated plates, &c., complete			

ZINC WORKER.

Super.	Run.		at £	s.	d.
	168	Of 6-inch gutter, worked and fixed as shown on details of roof, Plate XXI. No. 6 octagon heads, with shoes, &c., complete			
	210	Of 4-inch piping, for down-comers, fixed complete			
	80	Of 3-inch ditto, for ditto of entrance-porches and bay windows . .			

Quantities of the various Materials requisite for finishing and completing the Carcasses of two Houses; before calculated for.

JOINER'S WORK.

Feet Super.	Feet Run.	No.		at £	s.	d.
			FLOORS.			
1304	..	..	Or 13 square 4 feet of $1\frac{1}{4}$-inch white floor-boards, laid folding in attic and part of basement stories . . .			
3120	..	..	Or 31 square 20 feet yellow deal floor-boards, laid with a straight joint and splayed headings, for chamber, ground-floor, and part of basement stories . . .			
			GROUNDS.			
	120	..	$\frac{3}{4}$-inch grounds 2-inch wide, faced and chamfered, for attic			

JOINERS' WORK *continued.*

Feet Super.	Feet Run.	No.		at £	s.	d.
	250	..	Of 1-inch ditto, for chamber floor			
106	..	..	Of 1-inch splayed framed ground, $3\frac{1}{2}$-inch wide, for chamber floors . . .			
	330	..	Of 1-inch × $2\frac{1}{2}$-inch ploughed skirting grounds, for ground floor			
164	..	..	Of 1-inch ploughed and framed, and 5 inches wide, for door and windows (See Plate XXV.)			
			SASHES AND FRAMES.			
54	..	..	Of chamfered and rebated lights, with frames and finishings made complete according to the specification			
			VENETIAN WINDOWS— CHAMBER FLOOR.			
120	..	..	To front and back windows, with frames $1\frac{1}{2}$-inch, oval sashes, lining, and all finishing complete, as shown on the drawings and described in the specification . .			
120	..	..	Ditto for back-parlour and kitchen windows, with sashes, frames, suspended shutters, and all finishings complete			
52	..	..	Of small frames, sashes, and finishings complete, for small windows, &c.			
			BAY WINDOWS.			
390	..	..	Of frames, sashes, lining, soffit, and all other finishings complete . . .			

JOINERS' WORK *continued.*

Feet Super.	Feet Run.	No.		at £	s.	d.
			JAMB-LININGS.			
60	..	..	Of 1-inch beaded linings, with stops braided on, for attic and part of basement storey			
256	..	..	Of 1-inch beaded and single rebated ditto ditto . . .			
106	..	..	Of 1¼-inch beaded and double rebated ditto ditto . .			
			DOOR-FRAMES, DOORS, AND FINISHINGS.			
75	..	..	Of 1¼-inch two-panel square doors, for attics and part of basement			
280	..	..	Of ditto four-panel square doors, for ground-floor and part of basement . .			
188	..	..	Of 1¼-inch four-panel, moulded on both sides, for ground-floor and breakfast room .			
95	..	..	For entrance-hall door-frames, transom-head, fan-light, doors, and finishings, all complete (see specification)			
126	..	..	For back or garden entrance, door-frame, sash-door, side-lights, fan-lights, boxing shutters, and all other finishings complete . . .			
40	..	..	Of door-frame, with 1½-inch four-bead and butt complete, for cellar			
40	..	..	Frame, with transom-head light and 1½-inch sash door, lifting shutters, and all other finishings complete .			
			FRAMED PARTITIONS, WITH DOORS COMPLETE.			
729	..	..	Of 1¼-inch square panel, including 6 two-panel 1¼-inch doors complete, for store-closet and pantries . .			
140	..	..	Ditto, sash-partition and doors,			

JOINER'S WORK *continued.*

Feet Super.	Feet Run.	No.		£	s.	d.
			to divide stairs from lobby of garden entrance . .			
130	..	..	Of 1¼-inch sash partition, to divide stairs from water-closet			
			SKIRTINGS.			
160	..	..	Of ¾-inch skirting, six inches wide, for attic and part of basement floors . . .			
220	..	..	Of 1-inch ditto moulded, for chamber floors . . .			
270	..	..	Of 1-inch rebated ditto, for ground-floor and breakfast-room			
			MOULDINGS.			
	210	..	Of 1½-inch, to form architrave over grounds, and pilaster attic story			
	380	..	Of 2-inch, for chamber-floor .			
	280	..	Of 3⅓-inch for ground-floor and breakfast-room . .			
	120	..	Of 1½-inch for basement . .			
			WATER-CLOSET.			
112	..	..	Of mahogany seat and riser, dished to basin and handles			
32	..	..	Ditto mahogany-framed top, with moulded nosing, lining complete, and finished with skirting all round . . .			
25	..	..	Of mahogany wash-stand, with closet and shelves, &c., underneath			
7	..	..	Of mahogany doors to ditto .			
	3	..	Feet run of ½-inch skirting, six inches wide . . .			
8	..	..	Of rebated and beaded mahogany box, to cover service and supply-pipes . . (See specification for these privies.)			

JOINER'S WORK *continued.*

Feet Super.	Feet Run.	No		at £	s.	d.
			STAIRS FROM KITCHEN TO GROUND-FLOOR.			
80	..	..	Of 1¼-inch treads, properly blocked			
			Of 1-inch risers . . .			
40	..	..	Of 1¼-inch string boards with			
to 40	..	..	bracket housings and carriage complete			
			GEOMETRICAL CIRCULAR WELL-STAIRS, FROM GROUND TO CHAMBER-FLOOR.			
936	..	..	Of 1¼-inch yellow deal treads, risers, strings, and carriage; the risers mitred into external string, and treads moulded and mitred to return nosings, and the whole completed as shown on and described in specification			
		1	Blocked and veneered curtail step, with return to join external string . . .			
	32	..	Of 2½-inch sunk mahogany moulded hand-rail, wreathed to circular well, as well as to curtail step, and to be mitred into a hand-work mahogany cap, with all balusters complete to chamber landing, comprising the fixing of one ornamental baluster to curtail, and three plain ones on the flight .			
			STAIRS FROM CHAMBER-FLOOR TO ATTIC-FLOOR.			
136	..	..	Of treads, risers, strings, and carriage complete . . (See plan and specification.)			

PLASTERER'S WORK.

Superficial Yards.	Feet.	Run.		at £	s.	d.
1018	..	..	Of lath, plaster, float, and set to ceilings and partitions .			
484	..	..	Of render, float, and set on walls			
		240	Of cornice, 18-inch girth . .			
		188	Of ditto, 12-inch ditto .			
		236	Of ditto, 10-inch ditto .			
			STAIRS.			
65	..	..	Of lath, plaster, and stucco, to hall, passage, and stairs .			
70	..	..	Of render, set and float in stucco, on walls, &c. . .			
596	..	..	Of lime whitening . . .			

MASON.

Feet Super.	No.		at £	s.	d.
10	..	Of 1-inch rubbed York stone, for chimney-pieces in attic . . .			
	4	Chimney-pieces for chamber-floors .			
	4	Ditto ditto for ground-floors .			
	2	Ditto ditto for basement-floors .			
397	..	Of 2½-tooled York, for paving to areas and cellars, including steps . .			

FURNISHING IRONMONGER.

	ATTIC-FLOOR.	at £	s.	d.
No.				
8	¾-inch pivots, with patent cords, complete .			
8	pair of brass-cased pulleys			
24	yards of patent sash-cord.			
16	metal sash-weights			
8	2-inch springs sash-fastenings			
16	pair of 2½ butt hinges			
2	4-inch leaf spring latches			
2	4-inch iron closet locks			
4	6-inch mortice locks, with furniture, complete .			

FURNISHING IRONMONGER *continued.*

No.		£	at s.	d.
	WATER-CLOSET.			
4	pair of $2\frac{1}{2}$ butts			
2	$4\frac{1}{2}$-inch brass spring latches, complete			
	GROUND-FLOOR.			
12	brass-cased pulleys			
30	yards patent cord			
12	metal weights			
4	2-inch brass fastenings			
	revolving shutters, with all requisite finishing, to be estimated at so much each.			
	ENTRANCE-HALL AND BACK ENTRANCE.			
8	pair of 4-inch butt hinges			
4	best 10-inch draw-back mounted spring locks			
4	12-inch door-chains, brass-mounted, with asp, and all complete			
4	10-inch barrel bolts			
4	18-inch bow-latch shutter bolts			
4	3-inch brass spring-locks			
	SHUTTERS IN PARLOUR.			
4	1-inch brass flush rings			
4	brass clips for fastenings, with requisite pins			
8	pair of 3-inch butt hinges			
4	3-inch flush bolts			
6	6-inch mortice locks with furniture, complete			
	BASEMENT-STORY.			
10	pair of brass-cased pulleys			
30	yards patent cord			
20	metal weights			
2	6-inch mortice locks			
6	9-inch iron-rim locks, with furniture, complete			
12	10-inch barrel bolts, complete			
6	6-inch iron-rim locks, ditto			
24	pair of 3-inch butt hinges			
8	pair of $2\frac{1}{2}$-inch ditto			
1	ornamental cast baluster			
3	plain ditto ditto, 2 ft. 6 in. high, $\frac{3}{4}$ in. $\times$ $\frac{5}{8}$ in.			

BELL-HANGER. (*See specification.*)

PLUMBER.

Feet Run.		at £	s.	d.
300	Of 1¼-inch service-pipe to principal cistern, with fittings-up, complete . . .			
140	Ditto of waste into water-closet . . .			
100	Ditto to water-closet cistern and kitchen .			
	To fit up, complete, two of Warner's patent water-closets (see specification), and two single-valve closets, for secondary closets, in yard			
50	Of 1-inch service-pipe to the same . . .			

GLAZIER.

Feet Super.		at £	s.	d.
233	Of Newcastle seconds glass, bedded and well back puttied			
361	Of 21-ounce glass, the greater portion to be bradded, as well as back puttied (see specification)			

PAINTER.

Yards.	No.		at £	s.	d.
	4	Frames and sashes to attic . .			
	8	Venetian frames and sashes . . .			
	11	Ditto, usual size			
346	4	Times in oil			
		OUTSIDE WORK.			
37	..	To eaves, &c.			
40	..	To doors, iron-work, &c. . . .			
	4	Frames and sashes to attic . .			
	8	Venetian frames and sashes . . .			
	11	Ditto, usual size			
		All properly prepared and finished according to specification.			

PAPER-HANGER.

Yards.	Pieces.		at £	s.	d.
	30	For chamber-floor			
	27	For ground-floor			
	14	For basement			

These quantities only apply to the principal buildings (*the kitchen offices not being included*), but the whole may be executed for about 600*l.* each, or 1,200*l.* the pair

DESCRIPTION OF PLATES.

PLATE

I. Perspective view of the proposed pair of semi-detached cottages or dwellings.

II. Block-plan of ground, showing position of rain-water tank, drains, traps, siphons, &c., with a section describing their fall, current, &c., to and from the said tank to principal sewers.

III. Block-plan, showing position of buildings, gardens, yard, &c., and the situation of the gully-traps, siphons, &c.

IV. Basement-plan, comprising breakfast-room, kitchen, back kitchen, cellars, store-closets, water ditto, coal-cellars, pantries, with the position of their sinks, dressers, &c.

V. Plans of ground-floor, comprising porticoes, entrance-halls, dining-rooms, parlours, lobbies, &c., with stairs to front and back entrances, and roofs over offices.

VI. Plans of chamber-floor, arranged for front and back bed-rooms, front dressing-rooms, water-closets, roofs over offices, &c., &c.

VII. Plan of attics, consisting of two front and two back bed-rooms, with a portion of principal roof, gutters, &c.

VIII. Plan of roofs, showing chimney flues, roof of dormer lights ridge, flashing, hips, gutters, &c., &c.

IX. Entrance elevation.

X. Back elevation.

XI. Longitudinal section of carcass, showing flues, &c., with elevation of kitchen, offices, &c., and ground line of front and back of building.

XII. Transverse section of carcass, showing flues and position of stairs, with the height of story figured thereon, and the ground lines of back and front of building.

XIII. Traps for drain, &c., exemplified in six figures. Fig 1. The section of drain that can be easily cleaned without the neces-

PLATE

sity of removing any portion of the earth, &c. Fig. 2. A simple sort of trap applicable to this form of drain. Fig. 3. A section and plan of a drain trap to be formed of iron or earthenware. Figs. 4, 5, 6. A similar description exemplified for various purposes. *See Description*, page 5.

XIV. Plan and section of rain-water tank, with slate filtering machine, so applied as to be taken out for cleaning, &c.

XV. Plan of brick piers, sleepers, and joists, consisting of six figures, viz., Fig. 1. Plan of pier. Fig. 2. Section of pier sleepers and joists. Fig. 3. Transverse section of the same. Fig. 4. Plan of pier, sleepers, and floor-joists. Fig. 5. Method of notching sleepers for receiving floor-joists, &c. Fig. 6. Floor-joists, bridged for fixing upon sleepers.

XVI. Details of brickwork, exemplified in six figures. Fig 1. Footings of external and party walls. Fig. 2. Footings, showing projections for sleepers, &c. Fig. 3. Chimney breast, brick and wood trimmers, with herring-bone trussing. Fig. 4. Floor joists, with ditto. Fig. 5. The elliptical arch, with its radii for brickwork. Fig. 6. The segment of a circle for the same.

XVII. Details of brickwork for chimneys. Fig. 1. Plan of foundation. Fig. 2. Shows a different method with fenders. Fig. 3. Elevation of chimney breast, with chimney bars. Fig. 4. Section of the same and back. Fig. 5. Brick corbels.

XVIII. Plan and section of chimney breast and trimmers. Fig. 1. Plan. Fig. 2. Section of the same.

XIX. Details of floor-joists for first, second, and third floors, &c., with the application of their tension rods. Fig. 1. Plan of walls, wall-plates, floor-joists, tension-rods, &c. Section of end of the same. Fig. 3. A perspective sketch, showing their combination. Fig. 4. Transverse trusses to floor-joists. Fig. 5. Floor-joists, with sound boarding applied.

XX. Plan and section of a portion of roof. Fig. 1. Section showing the whole principal rafters at each hip. Fig. 2. Plan of the same, showing the position of whole and half principals,

XXI. Details of roof. Fig. 1. Part of principal rafter, with all auxiliaries, &c. Fig. 2. Head and foot of queen-posts, &c., with their clips and ties. Fig. 3. King-posts, tie-beams, rafters, &c.

PLATE

XXII. Details of entrance porch. Fig. 1. Section through head of porch showing bracket and cap of pilaster, the flat to be covered with lead. Fig. 2. Elevation of base with steps, &c.

XXIII. Transverse section, showing partitions. Fig. 1. Partition for ground and chamber floors. Fig. 2. Heads and sills of the same. Fig. 3. Struts and braces. Fig. 4. Plan of a portion of cistern in roof. Fig. 5. Section of the same, &c.

XXIV. Longitudinal section, showing partitions. Fig. 1. Partition for ground and chamber floors. Fig. 2. Head and braces. Fig. 3. Door heads.

XXV. Details of finishing for the various floors. Fig. 1. For doors, windows, &c., attic floor. Fig 2. Grounds and skirting chamber floor. Fig. 3. Windows, doors, &c., chamber floor. Fig. 4. Windows and doors, back parlour.

XXVI. Finishings for bay windows. Fig. 1. Portion of plan, showing sash frame, &c. Fig. 2. Section of the same.

THE END.

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SECTION OF GROUND. NOTE. VERTICAL TWICE THE SIZE OF THE HORIZONTAL

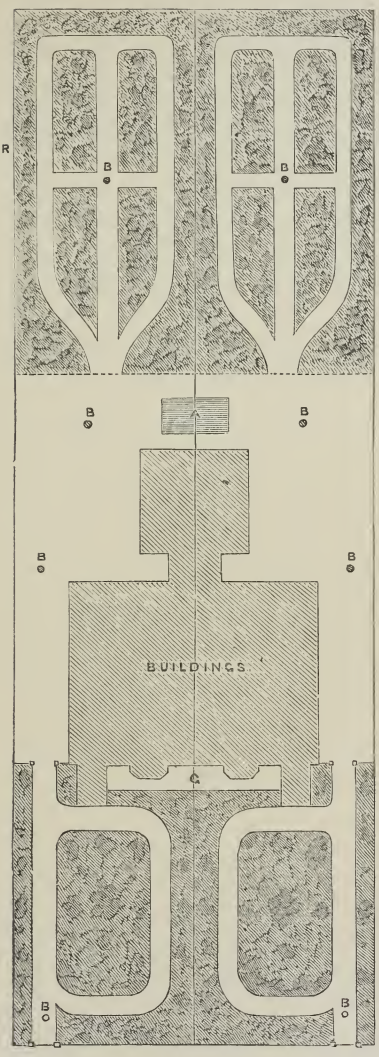
BLOCK PLAN OF GROUND, SHOWING WATER TANK DRAINS &c.

BLOCK PLAN. SHOWING BUILDINGS. &c.

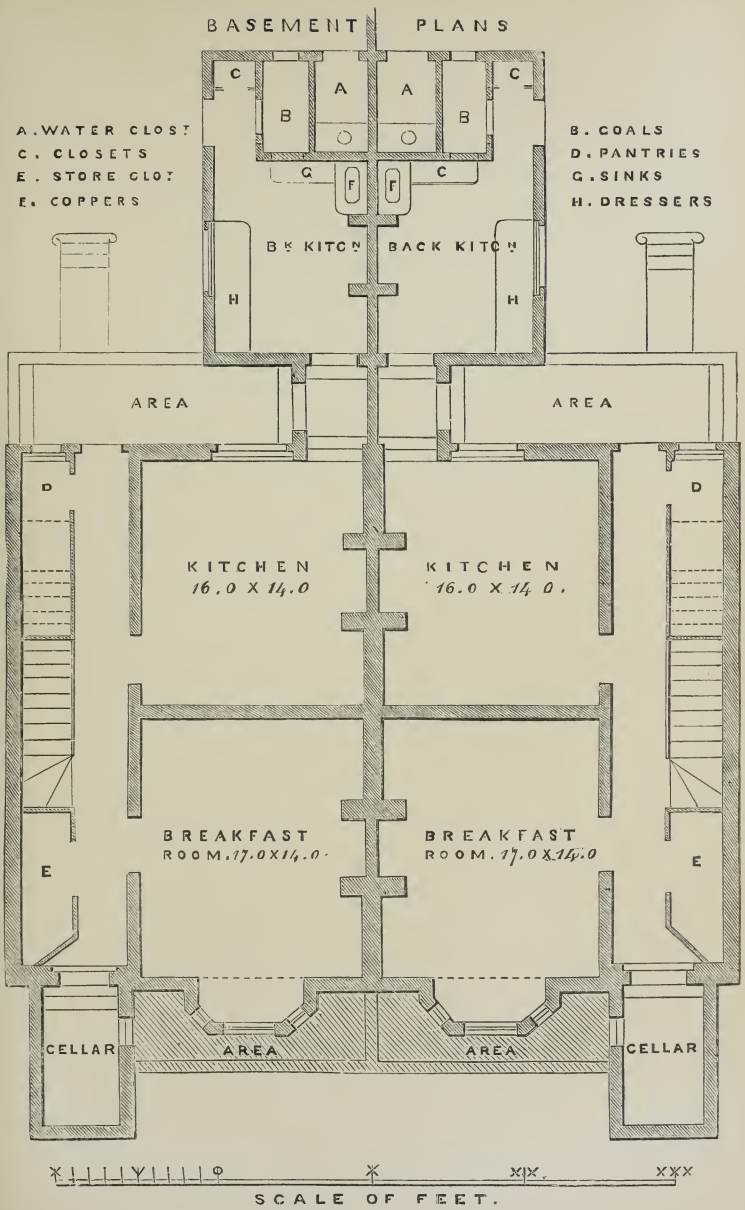
A. RAIN WATER TANK.

B.B. TRAPS.

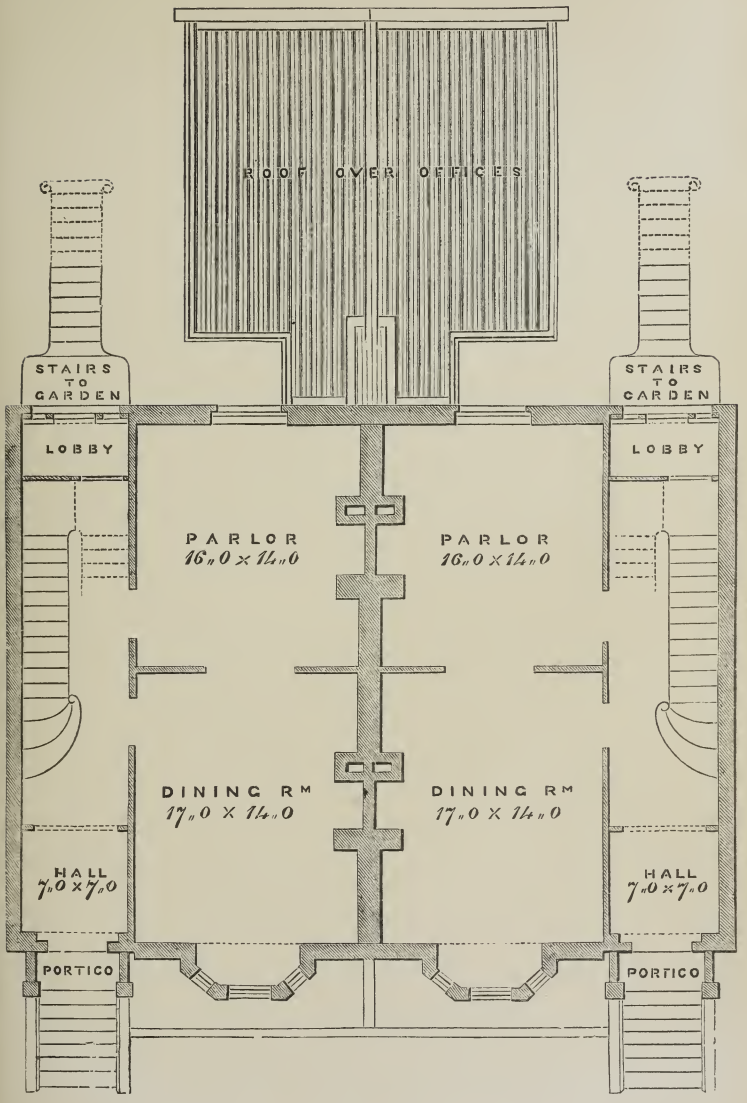
C. AREA.



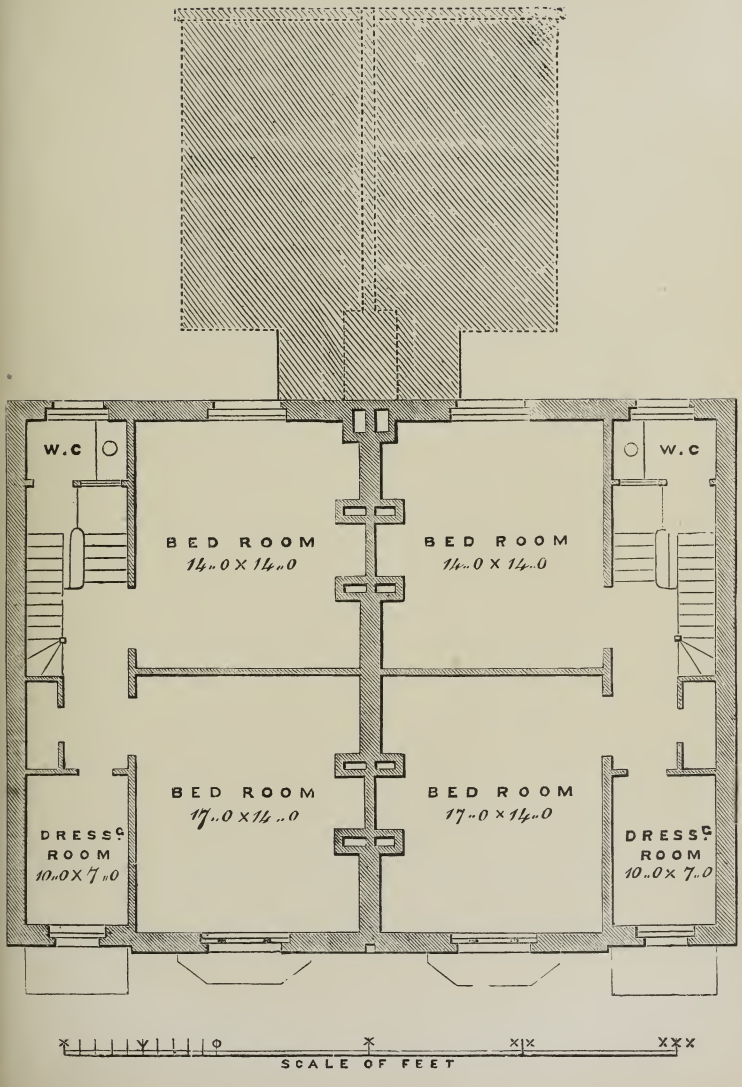
SCALE OF FEET


BASEMENT PLANS
A. WATER CLOSTS
C. CLOSETS
E. STORE CLOSTS
F. COPPERS
B. COALS
D. PANTRIES
G. SINKS
H. DRESSERS
C
B
A
A
B
C
G
F
F
C
BK KITCN
BACK KITCN
H
H
AREA
AREA
D
D
KITCHEN
16.0 X 14.0
KITCHEN
16.0 X 14.0.
BREAKFAST
ROOM. 17.0 X 14.0.
BREAKFAST
ROOM. 17.0 X 14.0
E
E
CELLAR
AREA
AREA
CELLAR
SCALE OF FEET.

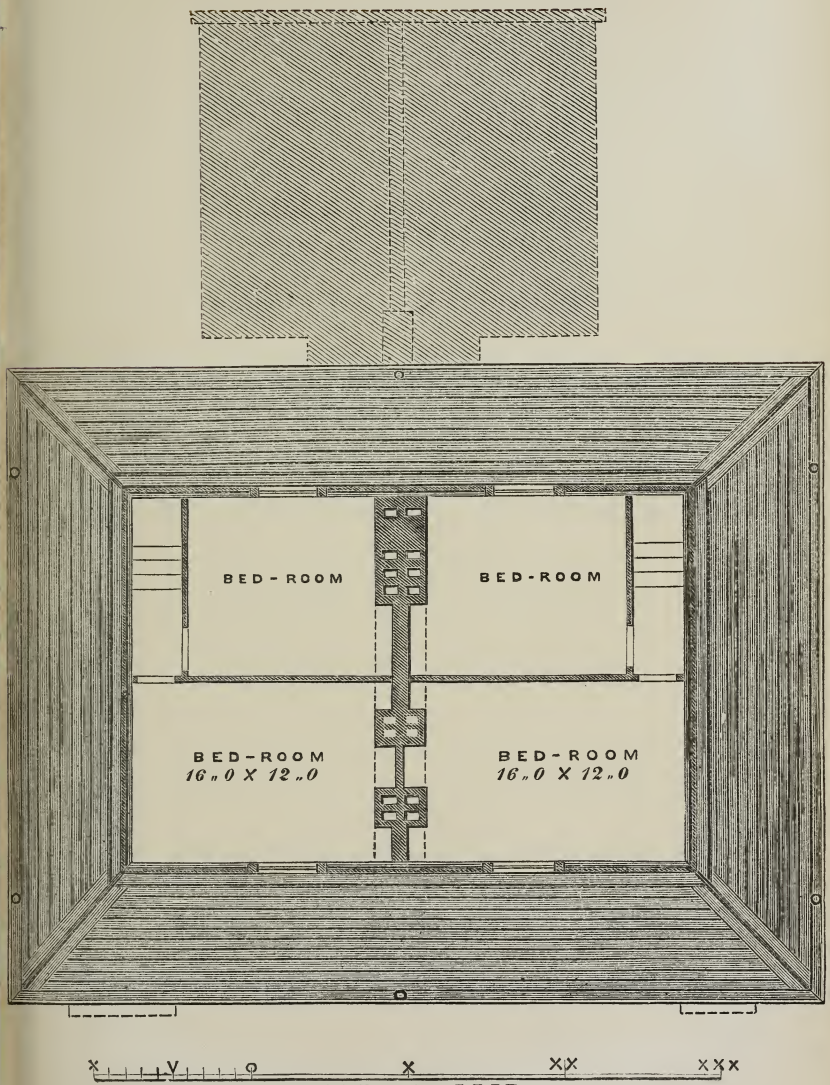
GROUND FLOOR PLANS



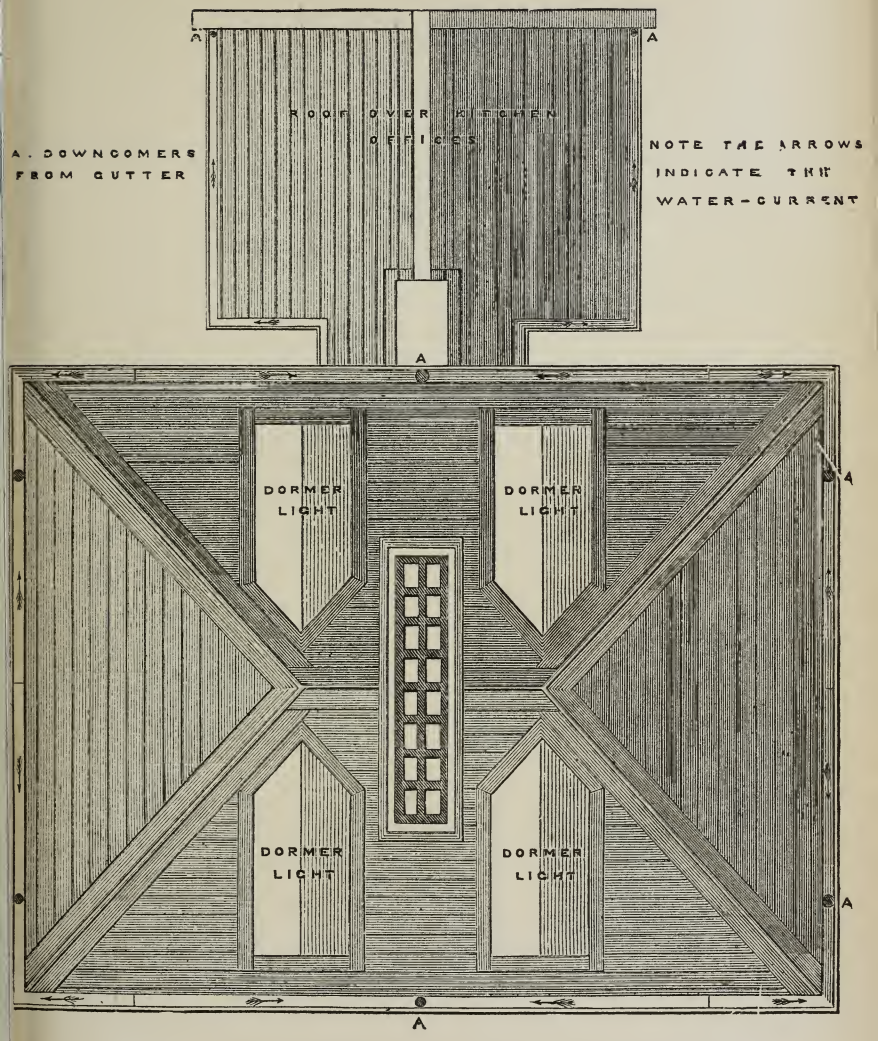
PLANS OF CHAMBER FLOOR.

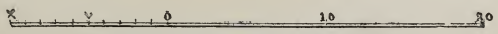


PLAN OF ATTICS.

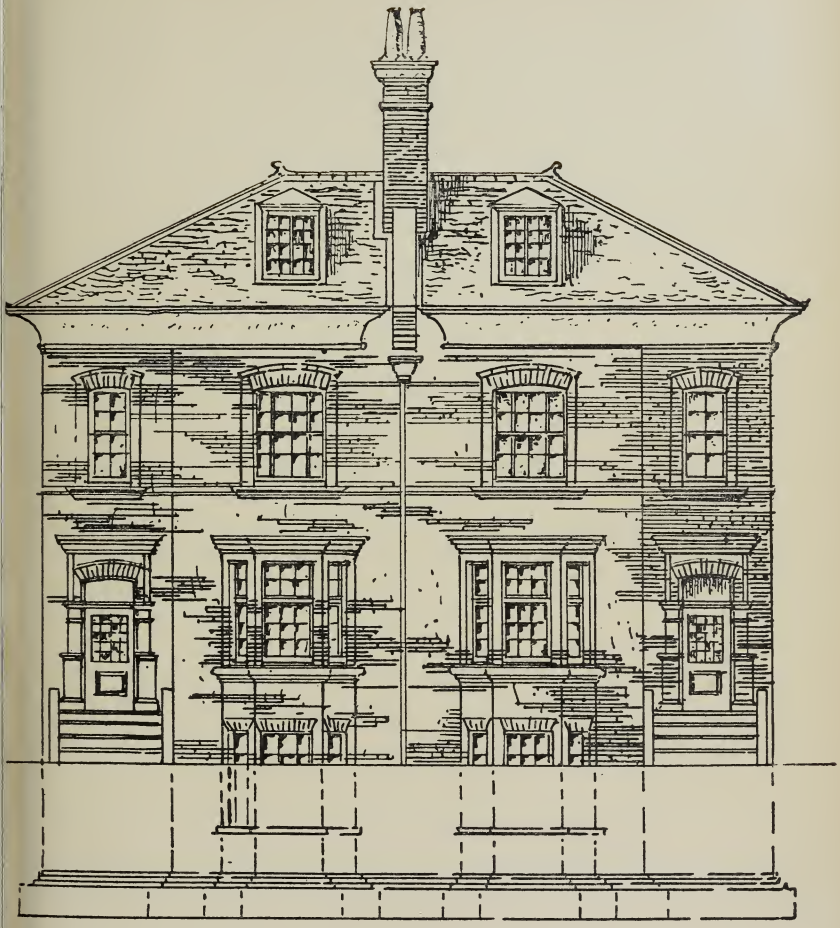


PLAN OF ROOFS.

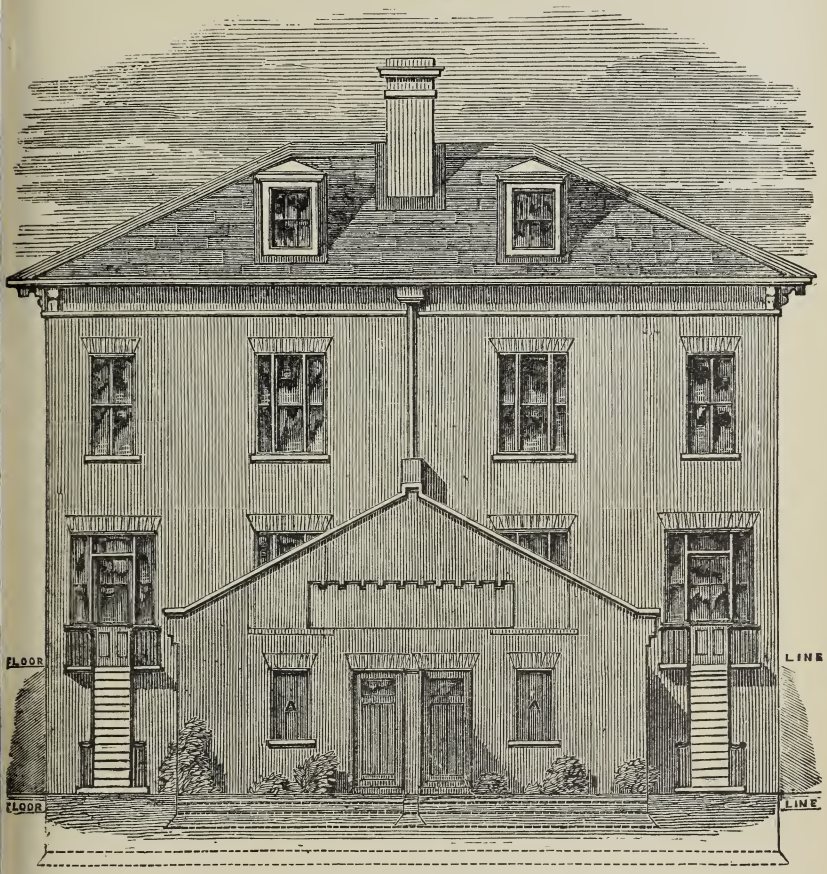




SCALE OF FEET.

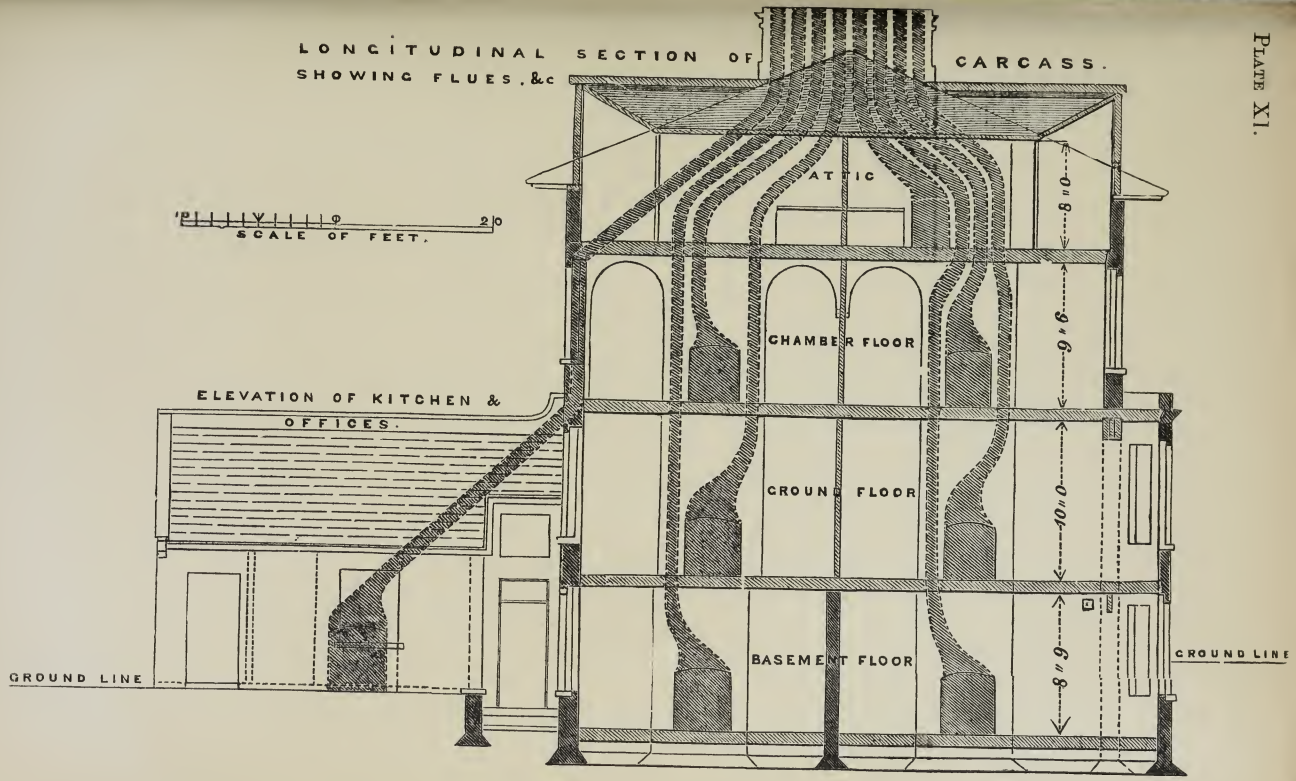


BACK ELEVATION.



A.A. COAL SHOOTS

SCALE OF FEET.


LONGITUDINAL SECTION OF CARCASS.
SHOWING FLUES, &c
SCALE OF FEET.
ATTIC
CHAMBER FLOOR
GROUND FLOOR
BASEMENT FLOOR
ELEVATION OF KITCHEN & OFFICES.
GROUND LINE
GROUND LINE
9' 8"
9' 6"
10' 0"
9' 6"

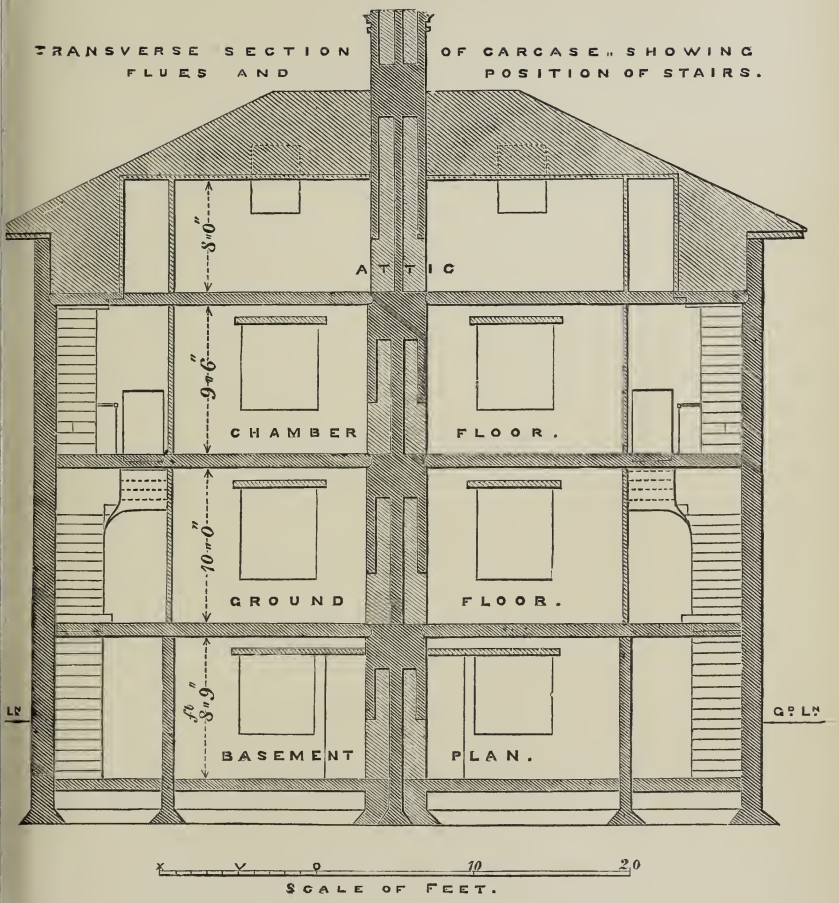
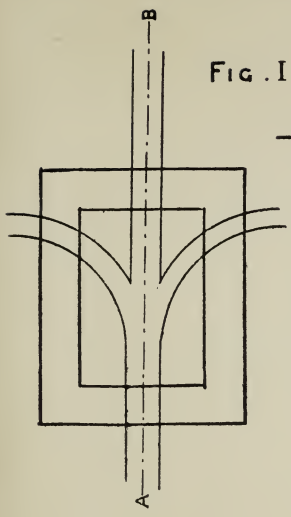
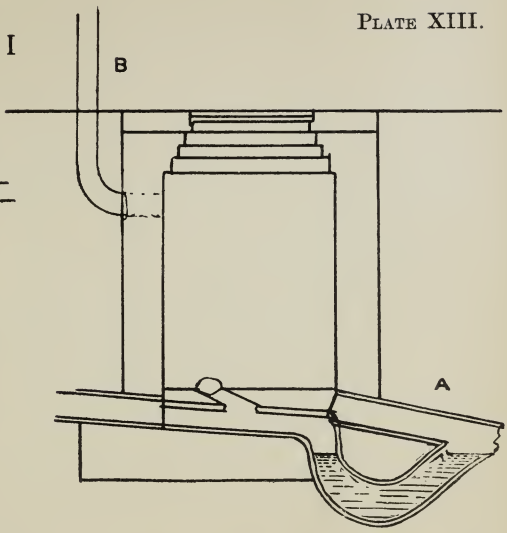

TRANSVERSE SECTION OF CARCASE, SHOWING FLUES AND POSITION OF STAIRS.
8'-0"
ATTIC
9'-6"
CHAMBER FLOOR.
10'-0"
GROUND FLOOR.
8'-9"
BASEMENT PLAN.
LN
GR LN
0
10
20
SCALE OF FEET.

FIG. I





PLAN.

SECTION A.B.

FIG. II.

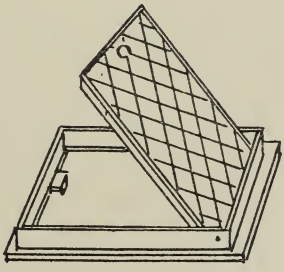


FIG. III.

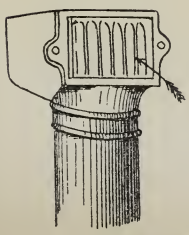


FIG. IV.

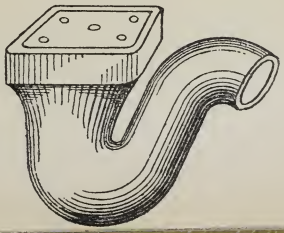


FIG. I. SECTION OF RAIN WATER TANK

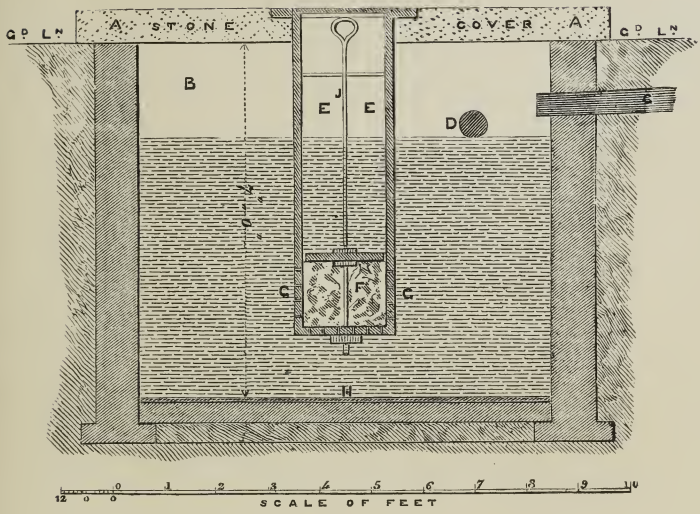
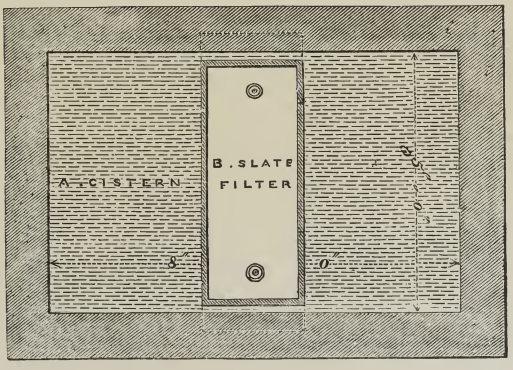


FIG. II. PLAN OF CISTERN



PLAN OF BRICK PIERS. SLEEPERS AND JOISTS.

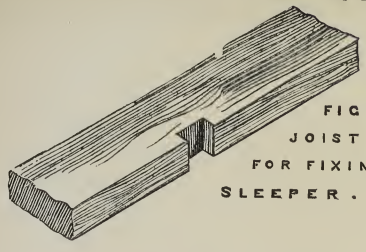


FIG. VI. FLOOR JOIST BRIDGED FOR FIXING UPON SLEEPER.

FIG. I. PLAN OF PIER

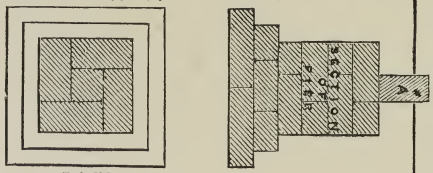


FIG. II. SECTION OF PIER AND JOIST

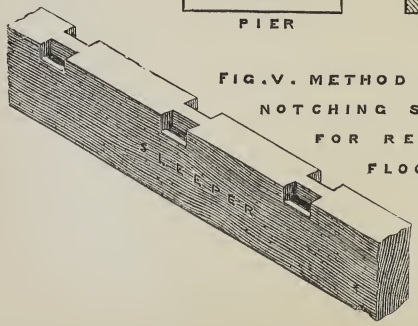


FIG. V. METHOD OF NOTCHING SLEEPERS FOR RECEIVING FLOOR JOISTS.

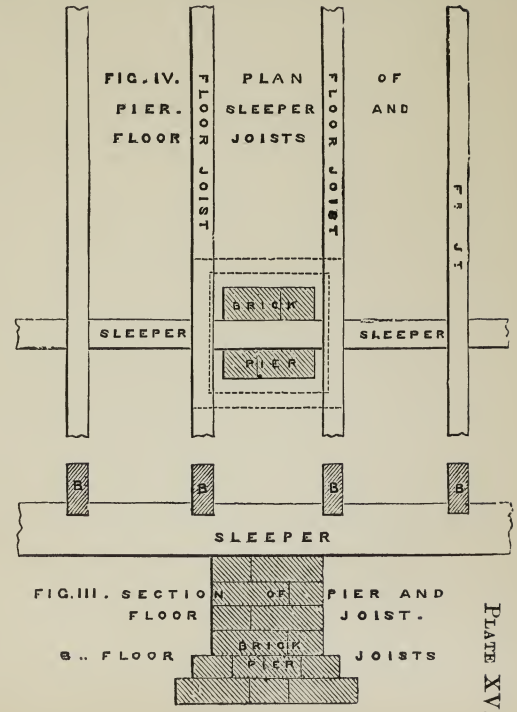


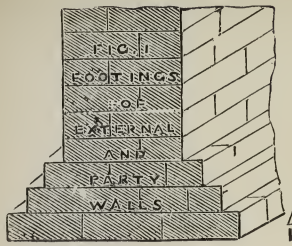
FIG. IV. PLAN OF PIER. FLOOR SLEEPER AND JOISTS

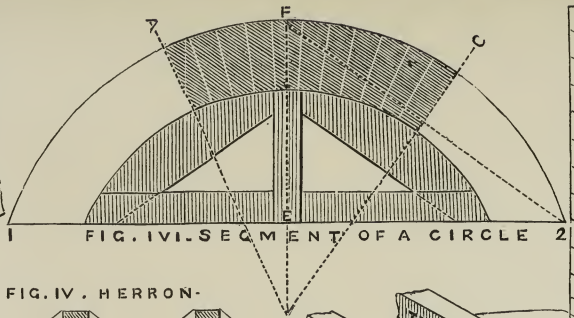
FIG. III. SECTION OF PIER AND FLOOR JOISTS.

B. FLOOR

PLATE XV.

DETAILS OF BRICKWORK.





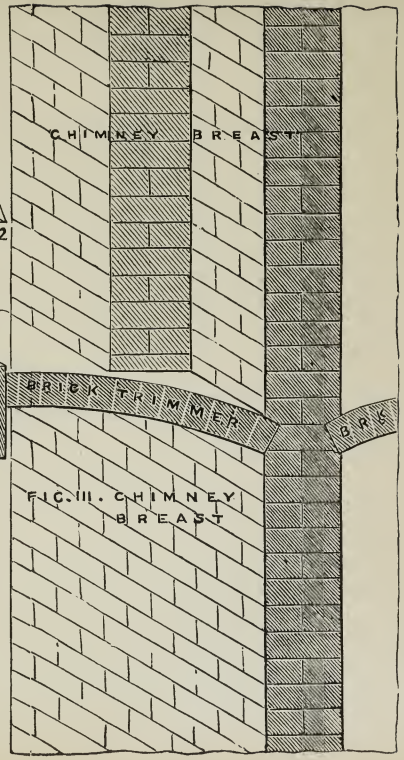
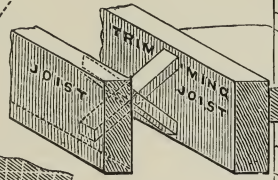
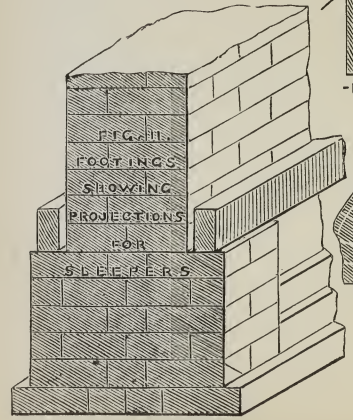


FIG. IV. HERRON-

A FLOOR JOIST





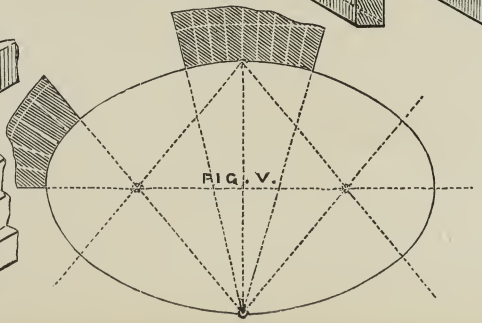
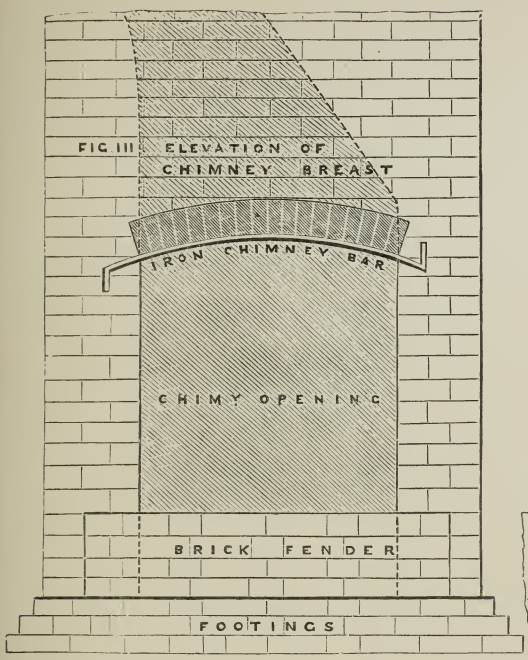
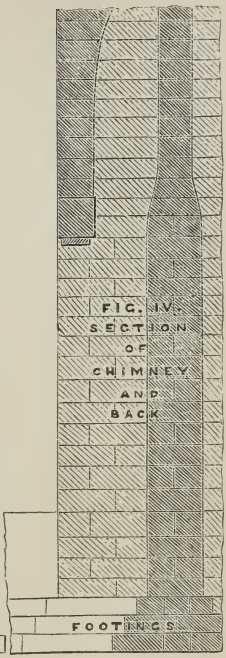


PLATE XVI.

DETAILS OF BRICKWORK FOR CHIMNIES





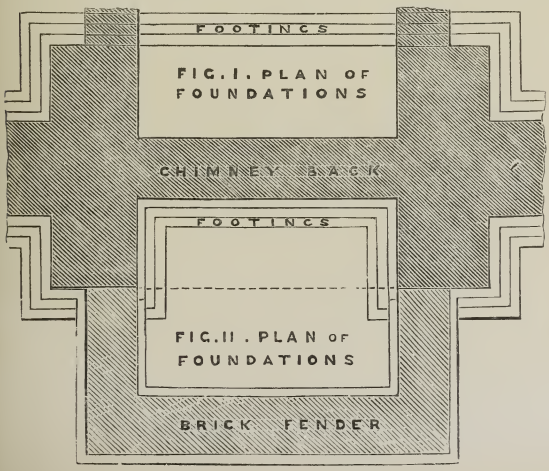
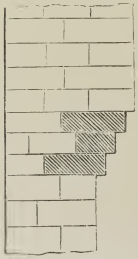


FIG. V. BRICK CORBEL.



PLAN AND SECTION OF CHIMNEY BREAST AND TRIMMERS.

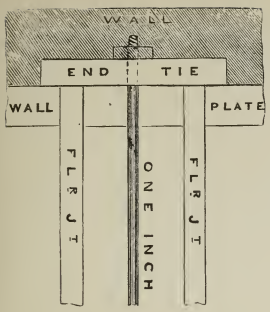


FIG. I.

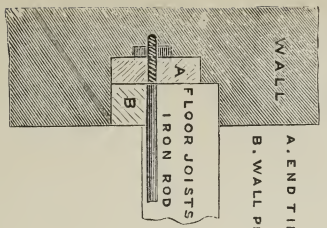
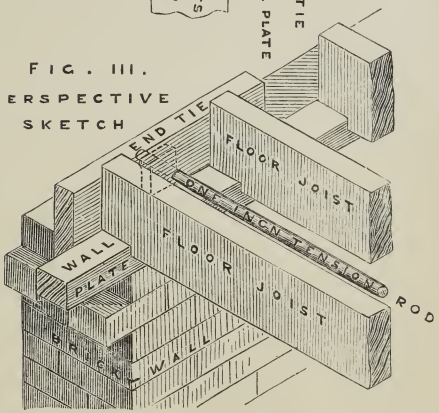
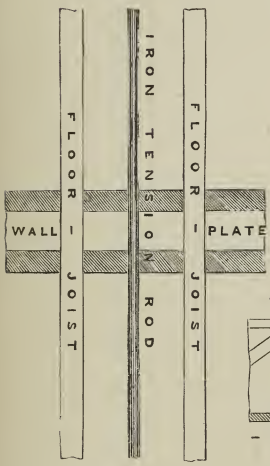


FIG. II. SECTION OF FIG. I

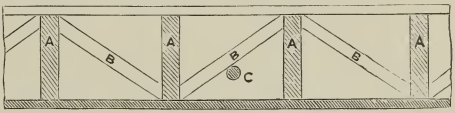
FIG. III.
PERSPECTIVE SKETCH





PLAN OF FLOOR JOISTS.

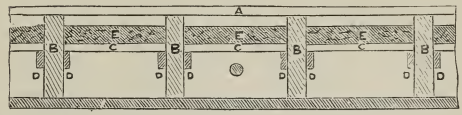
FIG. IV.
TRANSVERSE TRUSSES TO —.



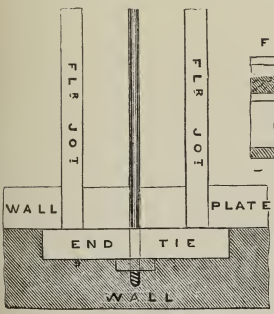
— FLOOR JOIST

A. JOIST
B. TRUSS
C. TENSION ROD

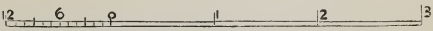
FIG. V.
FLOOR JOIST WITH SOUND BOARD-



— AND PUGING



A. FLOOR BOARDS
B. FLOOR JOISTS
C. SOUND BOARDING
D. FILLETS NAILED TO JOISTS
E. PUGING.



SCALE OF FEET

FIG. I. SECTION OF PORTION OF ROOF SHOWING THE WHOLE PRINCIPAL RAFTER AT EACH HIP.

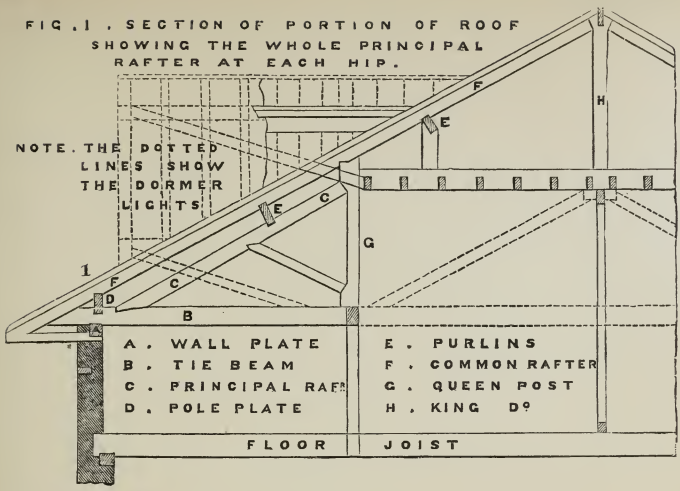
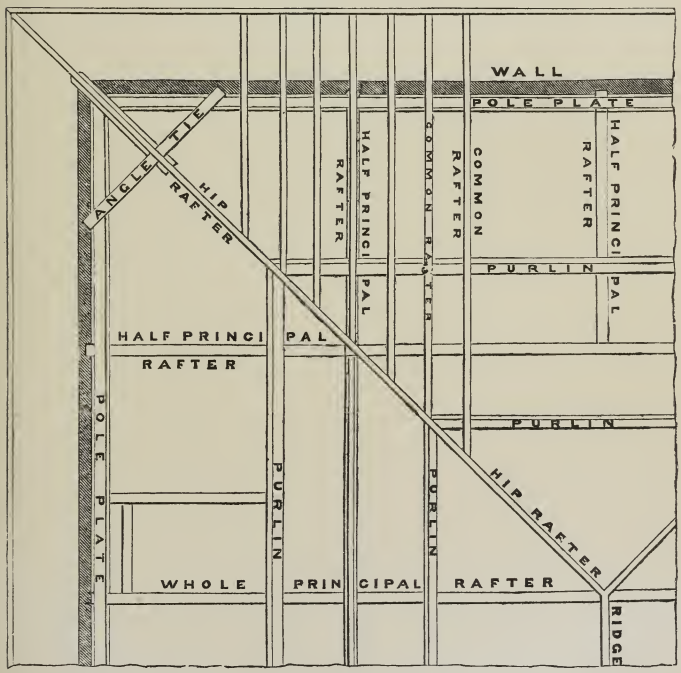
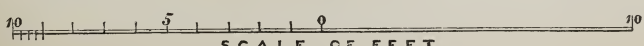


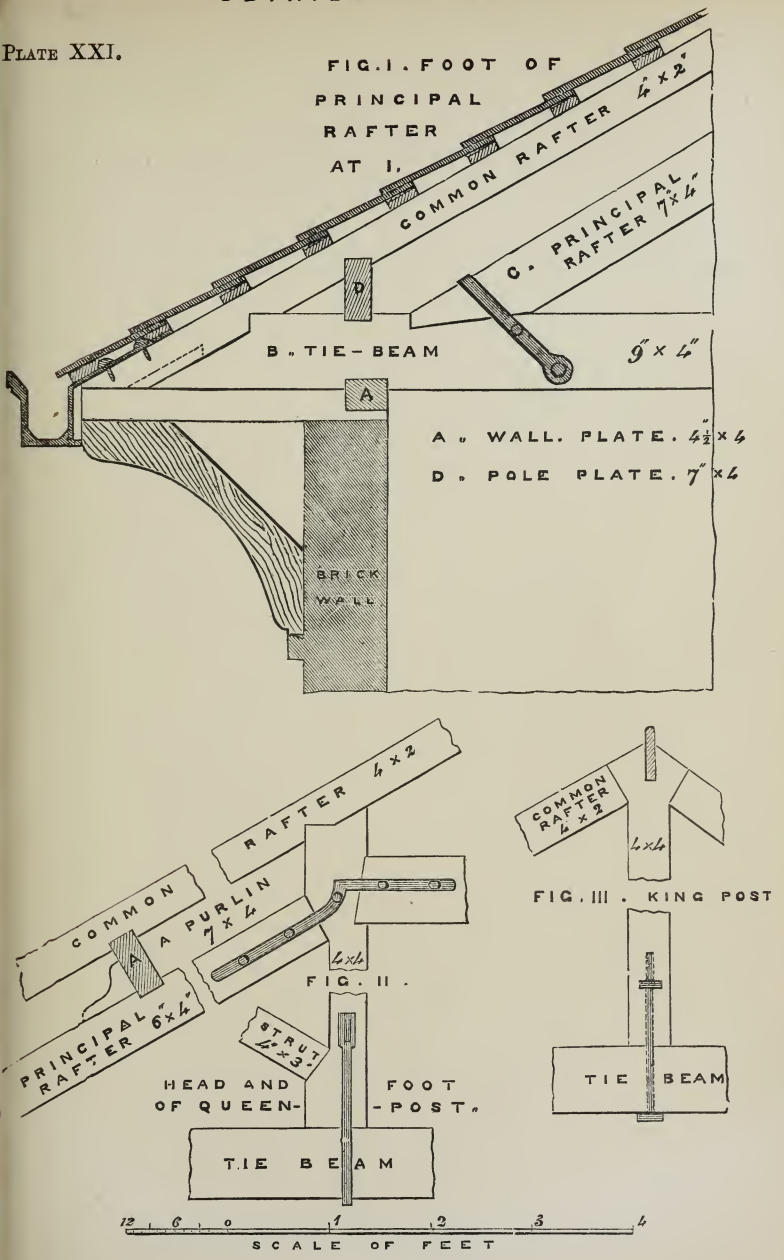
FIG. II. PLAN OF PORTION OF ROOF.





DETAILS OF ROOF.

PLATE XXI.



DETAILS OF ENTRANCE PORCH.

FIG 1. SECTION.

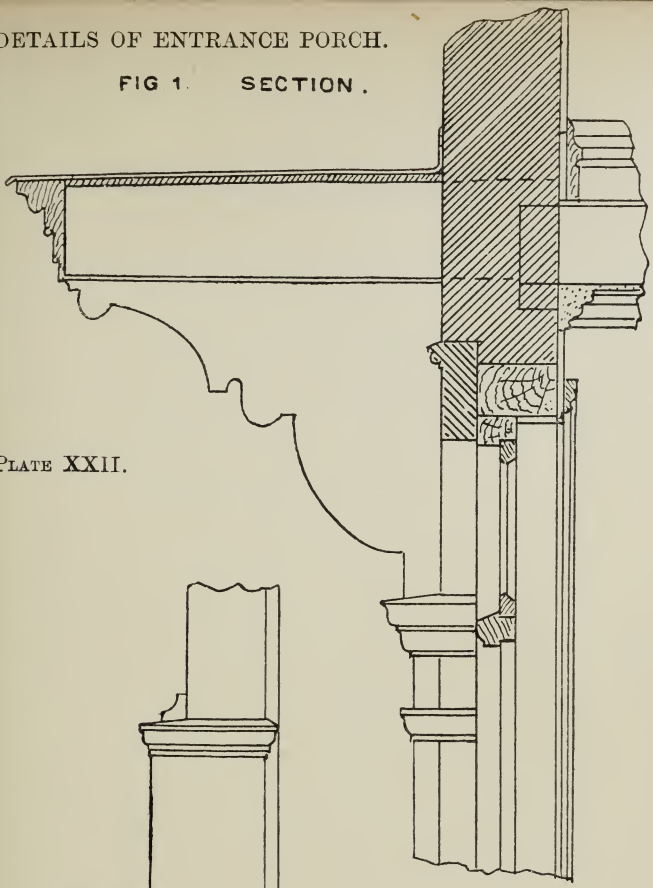


PLATE XXII.

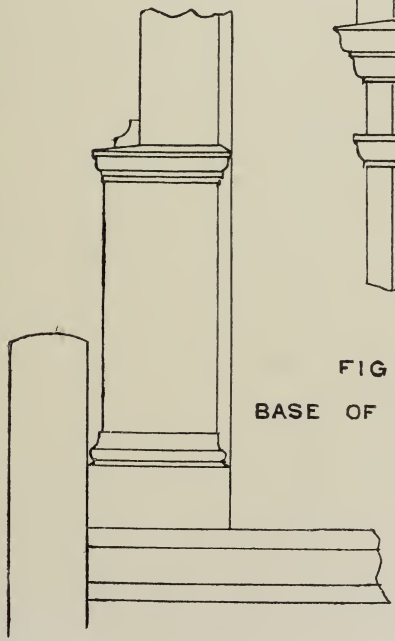
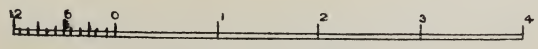


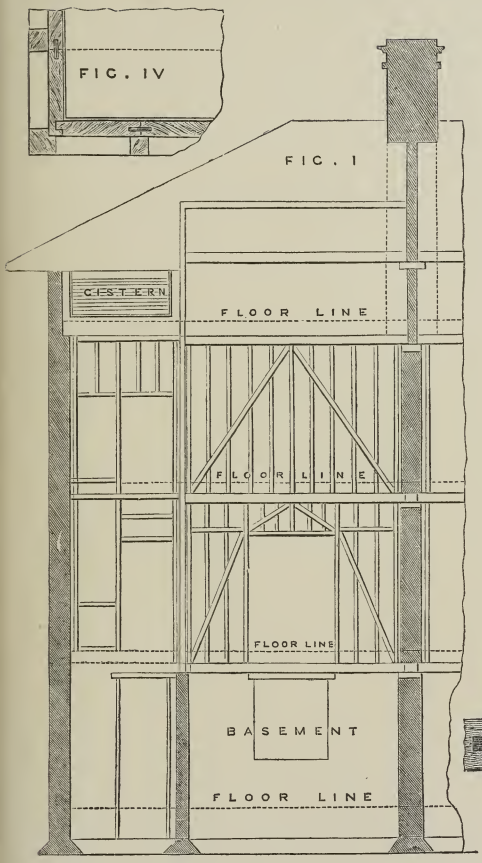
FIG. 2.

BASE OF PILASTER.



SCALE OF FEET

TRANSVERSE SECTION SHOWING PARTITIONS FROM A. TO B. ON PLAN.



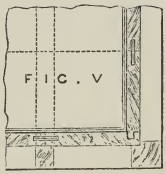


FIG III
STRUTS AT ANGLES

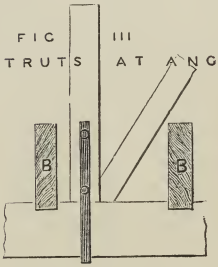
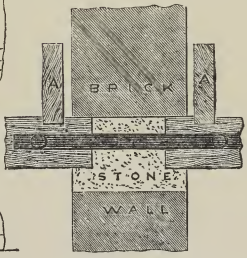
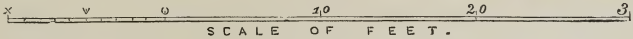


FIG. II. HEADS AND SILLS OF PARTITIONS





SECTION SHOWING PARTITIONS
FROM C. TO D. ON PLANS.

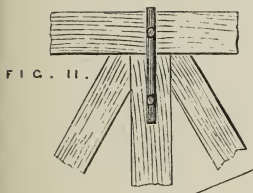
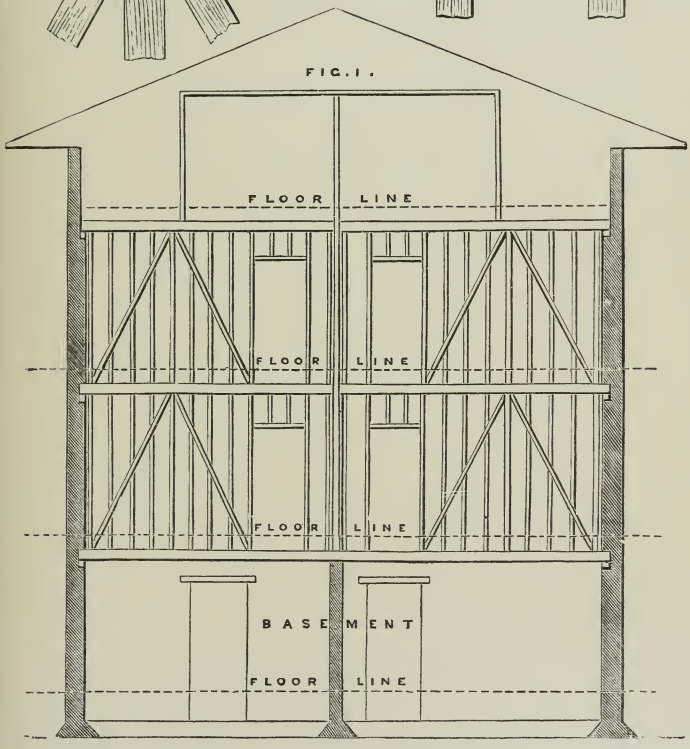
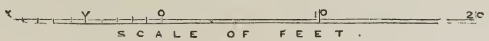


FIG. II.

FIG. III.

FIG. I.





DETAILS FOR FINISHINGS CHAMBER AND ATTIC FLOOR.

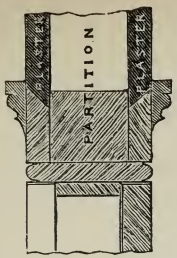


FIG. I. FOR DOORS. WINDOWS ATTIC.

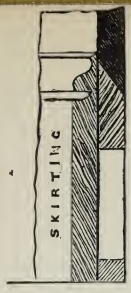
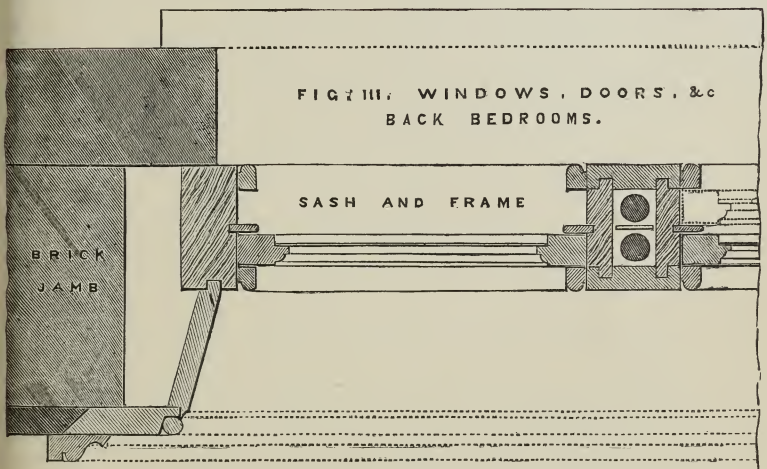
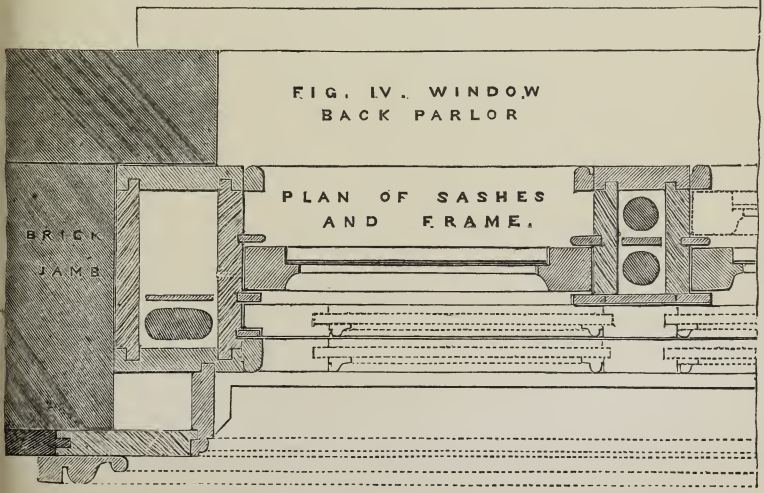
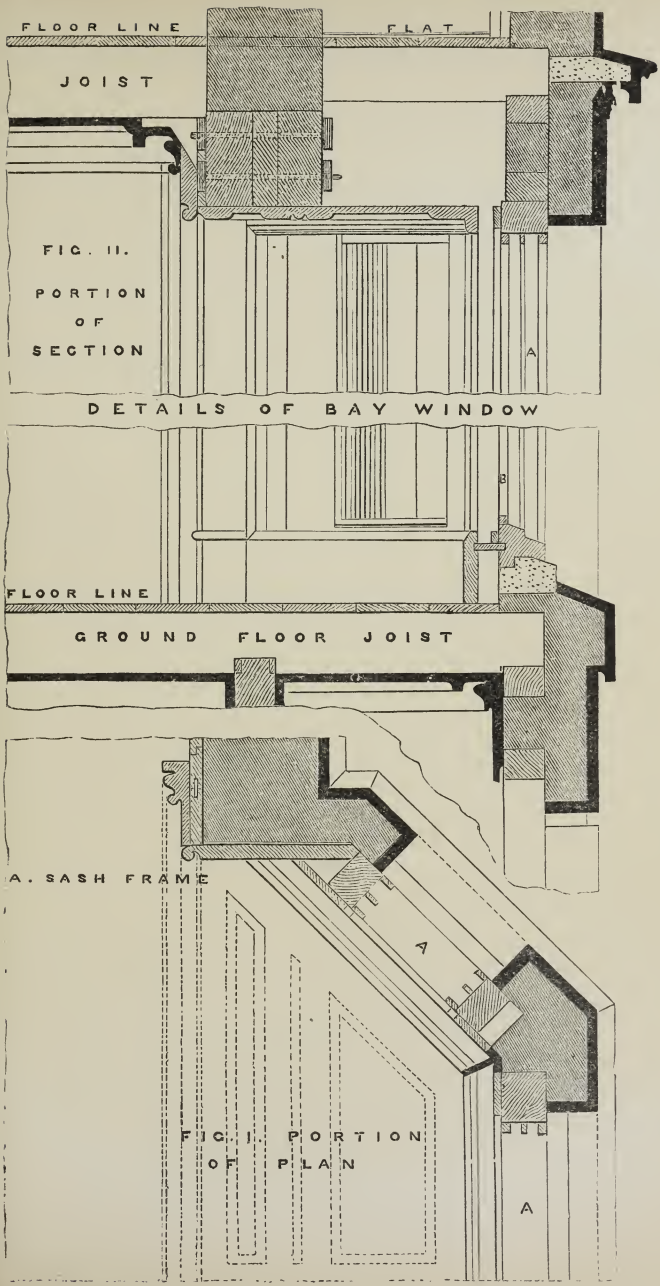


FIG. II. SKIRTING CHAMBER FLOOR






FLOOR LINE
FLAT
JOIST
FIG. II.
PORTION
OF
SECTION
A
DETAILS OF BAY WINDOW
B
FLOOR LINE
GROUND FLOOR JOIST
A. SASH FRAME
A
FIG. I. PORTION
OF PLAN
A

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